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# BIOTA OF FRESHWATER ECOSYSTEMS. IDENTIFICATION MANUAL NO. 8. FRESHWATER LEECHES (ANNELIDA: HIRUDINEA) OF NORTH AMERICA

Donald J. Klemm

Smithsonian Institution
Washington, D.C.

May 1972

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# FRESHWATER LEECHES (ANNELIDA: HIRUDINEA) OF NORTH AMERICA

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Biota of Freshwater Ecosystems

Identification Manual No. 8

# FRESHWATER LEECHES (ANNELIDA:HIRUDINEA) OF NORTH AMERICA

by

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for the

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# FOREWORD

"Freshwater Leeches (Annelida:Hirudinea) of North America" is the eighth of a series of identification manuals for selected taxa of invertebrates occurring in freshwater systems. These documents, prepared by the Oceanography and Limnology Program, Smithsonian Institution for the Environmental Protection Agency will contribute toward improving the quality of the data upon which environmental decisions are based.

Additional manuals will include, but not necessarily be limited to, freshwater representatives of the following groups: amphipod crustaceans (Gammaridae), branchiuran crustaceans (*Argulus*), isopod crustaceans (Asellidae), decapod crayfish crustaceans (Astacidae), polychaete worms (Polychaeta), freshwater planarians (Turbellaria), aquatic dryopoid beetles (Dryopoidea), and freshwater clams (Sphaeriacea).

ABSTRACT

An illustrated key to 63 species of North American freshwater leeches (Annelida:Hirudinea) is given with notes on their collection, preservation, important diagnostic features and distribution.



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## SECTION I

## INTRODUCTION

Historically, leeches are derived from an ancient protostome stock which gave rise to the annelids, thus establishing the metameric line. The earliest fossil annelids of the middle Cambrian indicate that they were already differentiated into well-established groups (such as Polychaeta, Oligochaeta, Hirudinea). The group (Annelida: Hirudinea) is relatively homogeneous, and the highly specialized annelids are thought to have arisen from an oligochaete progenitor.

Leeches are predominantly freshwater invertebrates, but there are many marine forms, as well as numerous terrestrial species, occurring mainly in the tropics. Unfortunately to the layman all leeches are popularly considered to be "bloodsuckers". However, their food habits are far more diverse than most people realize; many are not parasitic. These animals are predaceous, ectoparasitic, or scavengers with anterior and posterior suckers that serve as organs of attachment, feeding, and locomotion. They are morphologically adapted for obtaining and digesting food consisting chiefly of the blood of fishes, turtles, frogs, salamanders, birds and mammals; they may also consume carrion, blood fluids, tissues, and whole invertebrates, such as annelids (including leeches), insect larvae, and mollusks.

As a scientifically neglected group of invertebrates, they may, in the near future be more important in ecosystems, in invertebrate pathology, and as hosts to other parasitic forms, or even as vectors in the life cycles of parasites of other animals.

A number of keys to leeches have been published. Some of them are, as follows: Meyer (1946a) for fish leeches (Piscicolidae) in North America; Pennak (1953) for the United States; Moore, J. P. (1959) for North America; Mann (1962) for Central Europe, the British Isles, and North America; Soós (1963 to 1969b) for genera of the world with a catalogue of the species, and Davies (1971) for Canada. Other geographically restricted keys have been written: Moore, J.P. (1906, 1912, 1922) for the Great Lakes Region, Minnesota, and southern Canada; Bere (1929) for Jasper Park Lakes (Alberta, Canada); Miller (1929, 1937) for Ohio and Michigan; Eddy and Hodson (1950) for the north central United States; Moore, J.E. (1964, 1966) for Alberta; and Keith (1960) for Minnesota. All of these keys, however, have limited use because they are based on sparse collections; they also are in need of some of the recent important taxonomic changes made by Richardson (1969) and Soós (1963, 1965, 1966a, 1969a and b).

Since published leech accounts have been regrettably meager and widely scattered in various journals throughout the world, an expanded compilation has been prepared from published sources as well as from the late J. P. Moore's unpublished records and Soós (1970) records of zoogeographic distribution of the leeches of North America. It should be stressed

that previous keys have a more restricted number of species and have proven somewhat difficult to interpret and utilize. Therefore, the critical examination of leech collections and type specimens at the Academy of Natural Sciences in Philadelphia, especially those in the U. S. National Museum, Washington, D. C., and an extensive survey of the leeches of Michigan (Klemm, 1972) have provided materials which aided considerably in the preparation of this illustrated key. Notes have also been provided on important diagnostic characters, and they are intended to alleviate some of the problems inherent in earlier keys. This key is to be used primarily as a guide for determining the species of freshwater leeches of North America, north of Mexico, and might not serve effectively outside of that area.

By way of clarification of systematic difficulties Davies (1971) included *Erpobdella octoculata* (Linnaeus, 1758) in his key on the basis of an identification made by J. P. Moore of *Erpobdella atomaria* (Cavena, 1820), a new record for North America in Rawson (1953), but Moore, J. P. (1959) omitted them from his key. Soós (1966a) considered *E. atomaria* a variety of *E. octoculata* and recorded its distribution only in Europe and Japan. Mann (1961) and Soós (1968) stated that *E. octoculata* was restricted only to the Palaearctic Region.

There is still doubt concerning the correct generic rank for *Dina fervida* (Verrill, 1874), *D. microstoma* (Moore, J. P., 1901), and *D. bucera* (Moore, J. P., 1949). Moore, J. P. (1959), Mann (1961), and Meyer (1968) recognized *Mooreobdella* (Pawlowski, 1955) as a valid genus containing these three species. However, Soós (1966a and 1968), whose opinion is followed here, regarded *Mooreobdella* as a subgenus of *Dina*. For the purposes of this key *E. atomaria* and *E. octoculata* are ommitted and the name *Mooreobdella* is retained only in subgeneric rank.

Soós (1969b) lumped *Helobdella fusca* (Castle, 1900) and *H. lineata* (Verrill, 1874) into one species, *H. triseralis* (E. Blanchard, 1849); whereas, Moore J. P. (1952 and 1959) separated *H. fusca* and *H. lineata* taxonomically into two species. Because there remains some doubt concerning the correct species rank, *H. fusca* and *H. lineata* have been retained and *H. triseralis* omitted.

Finally, for each species recorded in the Species List and Ranges section, references are given to works containing more complete descriptions.

## COLLECTION

Leeches usually avoid light and are best collected by hand or gently with forceps. They are usually found attached to the undersides of stones, boards, logs, other objects littering the lake or stream bottom, submergent aquatic vegetation or masses of organic debris. Blood-sucking ectoparasites are sometimes collected with their hosts, but most freshwater species drop off after taking a meal. Some of the active swimming Hirudidae and Erpobdellidae can also be collected at night with a dipnet.

## PRESERVATION

In all species the identification is extremely difficult and often impossible because of unsuitable preservation. Therefore, if the leeches are dropped alive into preservatives such as 70% alcohol, 4% formaldehyde, etc., they contract strongly and such features as the eyes and the genital pores are difficult to discern. To get full advantage of this key, live leeches or well-preserved specimens should be used. For best results, live leeches should be narcotized in soda water (carbonated water), shreds of cigarette tobacco to give the water a faint tint, or in weak solutions of alcohol, chloroform, chlorotone, sodium nembutal, or propylene phenoxetol added very gradually over a 30 to 60 minute period. The leeches, depending on size, should be completely narcotized and relaxed in 30 to 60 minutes. Excessive relaxation in chloroform, chlorotone, etc., causes the furrows between the annuli to disappear. When the leeches no longer respond to probing or pinching with a probe or forceps, they are then rapidly drawn between the fingers and washed so that the mucus secreted during the preceeding process is washed off. Seventy-percent alcohol is injected into the body cavity of Erpobdellidae to insure preservation of the reproductive organs which might be necessary for positive identification. Next the leeches are straightened and placed between two glass plates or back to back Petri dishes with only slight pressure so they are held in normal position and not permanently flattened. Thus the leeches are kept in and extended position without displacing or distorting internal organs. This preparation is then immersed in a fixative (2% formaldehyde) to fix the leeches in this position. After the fluid has thoroughly penetrated and the leeches have fully stiffened, they are removed, washed and placed in vials or jars containing 80% alcohol.

## IDENTIFICATION

The diagnostic features which are very important in leech identification are: size of mouth, eye number and position, relative size of suckers, presence or absence of papillae, tubercles, and pulsatile vesicles, number of annuli between the male and female gonopore, the male reproductive system in some species, and annulation. Color differences occur within some species. In the key color refers to living leeches and those colors that are known to persist for several years with proper preservation. In some specimens that have been preserved for a period of time, color changes occur by the action of the preservative, and the deeper pigments may be completely obscured by the opacity of the surface tissue. In some cases it is important that the living color be noted on the label. In the key, reference is made to internal anatomical features of some species. Dissection is, therefore, necessary. If reference is made in a couplet to an internal feature after reference to an external one, the key can be used without resorting to the dissection provided the external features are clearly seen. Internal dissections are sometimes necessary in the examination of the genital atrium and atrial cornua to distinguish the *Dina-Mooreobdella* complex, *Nephelopsis obscura*, and in the examination of the jaws and teeth for the identification of some Hirudidae.

The body of the leech consists of 34 somites or segments designated I through XXXIV; each somite is represented by a ganglion in the central nervous system. Characteristically, each neuromeric somite is divided externally by superficial furrows in 2-16 rings or annuli. Somites that have the full number of annuli (termed complete or perfect somites) are found in the middle of the body and this number is generally characteristic of the genus or species. Incomplete or abbreviated somites occur at both ends of the body. The annuli features are best seen after careful narcotization. The specimen should be blotted dry and examined in air under oblique illumination, and the annuli features can be most easily seen in the lateral margins of the ventral surface.

Moore (1898) recognized that the nerve cord ganglia are placed in the middle annulus of the somite. The recognition of the triannulate somite is basic, and also that more complex divisions may be derived by repeated binary division of the annuli. Counting from the head end, those of the three primary annuli are numbered a1, a2, a3. Annulus a2 (the neural or sensory annulus) contains the ganglion and is marked externally by transverse rows of minute, cutaneous sensillae (segmental receptors). Repeated bisection of the three primary annuli give more complex annulation, b1, to b6; repeated subdivision give tertiary annuli c1 to c12, and quaternary annuli d1 to d24. The annular composition of complete somites is usually characteristic of genera and the composition of incomplete somites is frequently characteristic of species.

In addition to the sensillae, which are confined to the sensory annuli, other visible surface organs are the eyes, papillae, and tubercles. When present on the caudal sucker the simplest ocelli, which are imbedded in pigment, are termed oculiform spots (Fig. 3a). They are usually present in the Piscicolidae but are absent in the Glossiphoniidae. The number

and position of the eyes are important taxonomic features. The Glossiphoniidae have one to four pairs of eyes, the Piscicolidae zero to two pairs, Erpobdellidae have three or four pairs (except *Dina anoculata* which has none), and the Hirudidae five pairs of eyes. In *Batracobdella* and sometimes in *Glossiphonia* coalescence of the eyes may occur (Fig. 6h-j). The lobed nature of the eyes usually indicates the original condition.

The relative distance between eyes is another important diagnostic feature in identificiation (Fig. 6a-d). If the distance between them is equal to or greater than the eyes, they are termed well separated; if they touch they are termed fused, and if the distance between a pair of eyes is less than the diameter of a single eye, they are termed close together. In the Erpobdellidae the eyes are arranged in separate labial and buccal groups (Fig. 4b-d), and in the Hirudidae the eyes are arranged in a submarginal arch (Fig. 4a). If the leech has been fixed and the eyes cannot be seen, the head can be flattened between two glass slides. If the eyes are hidden by pigment, decolorize the head by immersion in 5% caustic potash (Mann, 1961). Papillae are limited to the small, minute protrusible sense organs that are often scattered in small or great numbers over the dorsal surface. Tubercles are the large, smooth, conical, or rounded cone projections that include some of the dermal tissues and muscles, and they often themselves covered with papillae. The arrangement of the papillae and tubercles is an important characteristic in distinguishing certain of the *Helobdella* and *Placobdella*. In *H. punctatolineata* tubercles are absent; in *H. lineata* they are small, smooth, and conical; in *H. fusca* they are absent or limited to the middorsal line of the posterior somites; and in *H. papillata*, the tubercles are prominent in five to nine longitudinal rows. In *P. ornata* numerous tubercles are present; the surface of the tubercles is covered with papillae which results in a very rough or warty appearance. In *P. parasitica* the tubercles are inconspicuous or absent; in *P. multilineata* they are small and more uniform; and in *P. papillifera* they are small, white but conspicuous in five longitudinal rows.

The anterior suckers of leeches are diagnostic and may be very prominent or simply consisting of the expanded lips of the mouth. In the Glossiphoniidae the anterior sucker is small and only slightly distinct from the body, but in the Piscicolidae the anterior sicker is always expanded and usually distinctly marked off from the body. The posterior sucker is generally directed ventrally. In all the Piscicolidae (except *Myzobdella*, *Illinobdella*, and *Piscicolaria*), the body is divided into two distinct regions (Fig. 3a): a narrow anterior (trachelsome) region, and a longer and wider posterior (urosome) region. In the genera *Piscicola* and *Cystobranchus* only, the neural annuli of the urosome bear 11 pairs of pulsatile vesicles. In *Piscicola* the vesicles are small and sometimes invisible in preserved specimens but in *Cystobranchus* the pulsatile vesicles are large and clearly visible in both living and preserved individuals.

The alimentary canal is a tube from mouth to anus and is divided into the buccal chamber, pharynx, esophagus, stomach or crop, intestine, and

rectum. In the Rhynchobdellida the mouth is a small pore within the anterior sucker, on the rim of it, or in the center of the sucker, (Fig. 1a-c). The pharynx of the Rhynchobdellida is muscular and protrusible through the mouth as a proboscis. In the Gnathobdellida and Pharyngobdellida the mouth is medium to large (Fig. 1d-f) and occupies the entire cavity of the anterior sucker. In the Hirudidae, the buccal cavity, which may or may not contain jaws, is separated from the cavity of the sucker by a flap of skin called the velum (Fig. 14a,b). The presence or absence of papillae on the velum in the key can also be used as a diagnostic feature between *Bdellarogatis plumbea* (papillate) and *Mollibdella grandis* (smooth). All other Hirudidae have three muscular jaws (two ventrolateral and one dorsomedial). The free edge of each bears teeth arranged in either one (monstichodont) or in two (distichodont) rows. To examine the velum and jaws the specimen should be pinned out; a median incision should be made from the lower lip of the anterior sucker back far enough for the margins to be pinned out to expose the inner surface of the pharynx. Details of the teeth can only be seen by removal of a jaw and making a temporary or permanent mount on a microscope slide.

The anus of most species opens on the dorsal surface a few annuli anterior to the posterior sucker (except in *Placobdella pediculata* and *Illinobdella richardsoni*). In *P. pediculata* it opens between somites XIII and XXIV with the posterior annuli forming a slender stalk (peduncle) bearing the posterior sucker and in *I. richardsoni* the anus opens 15 annuli anterior to the posterior sucker.

Leeches are hermaphroditic. The male and female gonopores are visible on the middle of the ventral surface of somites XI and XII and are generally separated by two to five annuli. The male gonopore is large, more readily visible, and anterior to the female gonopore. The female pore is often difficult to see. It is seen most easily immediately after narcotization; its position often being revealed by some color difference which is sometimes lost during fixation.

The female reproductive system comprises a pair of ovisacs, terminating in ducts which join to form a common duct or vagina. The male reproductive system consists of testisacs in metameric patterns (five to six in Rhynchobdellida and nine to ten in Hirudidae) but in the Erpobdellidae they are small, numerous, and arranged in grape-like clusters. The vasa efferentia connect the testisacs to the vasa deferens on each side. These ducts lead into the seminal vesicle and ejaculatory duct which opens into the atrium. The atrium is a median chamber and consists of three parts: a thin-walled eversible bursa, a thickened-walled glandular chamber, and a muscular median one, as well as a pair of lateral horns (atrial cornua), which receive the ejaculatory duct. In *Nephelopsis obscura* the atrial cornua is spirally arranged like a ram's horn (Fig. 16), but in the *Dina-Mooreobdella* complex the cornua are simply curved, globular, rounded, ellipsoidal, or short and curved, (Fig. 17a-e). Some species also have ejaculatory ducts with or without long preatrial loops (Fig. 17a-e).

To confirm diagnostic features of the internal reproductive system, dissection is necessary. The best way to accomplish this is to pin the preserved specimen out with the ventral surface up. A transverse incision should then be made across the body four or five annuli posterior to the male gonopore. Cuts should then be made anteriorly up the lateral margins of the body for about 26 annuli. The posterior edge of the flap thus made can now be lifted forward to expose the inner tissue which can be cleared away to fully expose the atrium and preatrial loops.

External copulatory glands with pores are present in a linear pattern of either four, eight or 28 (Fig. 13 a-c) on adult *Macrobdella decora*, *M. ditetra*, and *M. sestertia*. These copulatory glands are located five annuli posterior to the female gonopore.

*Glossiphonia heteroclita* and *Marvinmeyeria lucida* are two unusual species in that the male and female ducts open into a single gonopore.

In the Pharyngobdellida, the genera are separated on the pattern of annulation. While *Erpobdella* has all its annuli of similar size, *Dina-Mooreobdella* complex and *N. obscura* have every b6 annulus larger than the others and subdivided or partially divided by a faint transverse furrow (Fig. 15a, b).

Names in brackets [=] are synonyms used in older taxonomic keys. The average size of each species is given in the key but many variations appear in the species.

## SECTION II

## SPECIES LIST AND RANGES

Phylum Annelida

Class Hirudinea Lamarck, 1818

Order Rhynchobdellida Blanchard, 1887

Family Glossiphoniidae

Genus: *Actinobdella* Moore, 1901

*Actinobdella annectens* Moore, 1906 (Refs 1,20,29)
Continental Distribution: North America
North American Distribution: Canada (Ontario)

*Actinobdella inequiannulata* Moore, 1901 (Refs 1,20,32)
Continental Distribution: North America
North American Distribution: USA (Illinois, Michigan, Minnesota, Ohio)

*Actinobdella triannulata* Moore, 1924 (Refs 1,20,28)
Continental Distribution: North America
North American Distribution: Canada (Ontario), USA (Michigan, New Hampshire, Virginia)

Genus: *Batracobdella* Viguier, 1879

*Batracobdella michiganensis* Sawyer, 1972 (Ref. 46)
Continental Distribution: North America
North American Distribution: USA (Michigan)

*Batracobdella paludosa* (Carena, 1824) (Refs 13,51)
Continental Distribution: North America, Palearctic Region
North American Distribution: Canada (Nova Scotia)

*Batracobdella phalera* Graf, 1899 (Refs 1,7,58,59)
[= *Placobdella phalera* (Graf)]
Continental Distribution: North America
North American Distribution: Canada (Manitoba, Nova Scotia, Ontario, Quebec), USA (Colorado, Connecticut, Florida, Iowa, Michigan, New York, Ohio, Wisconsin)

*Batracobdella picta* Verrill, 1872 (Refs 1,2,29,51,54,58,59)
[= *Placobdella picta* (Verrill)]
Continental Distribution: North America
North American Distribution: Canada (Ontario, Quebec), USA (Arkansas, Colorado, Connecticut, Louisiana, Michigan, Missouri, New York, Ohio, South Dakota, Utah, Virginia, Wisconsin)



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Genus: *Glossiphonia* Johnson, 1816

*Glossiphonia complanata* (Linnaeus, 1758) (Refs 2,8,30)
Continental Distribution: North America, Europe, Asia (Kashmir, China, India, Japan), Africa (Belgian Congo), South America (Argentina ?)
North American Distribution: Canada (generally distributed), USA (Alaska, California, Colorado, Connecticut, District of Columbia, Florida, Idaho, Indiana, Illinois, Iowa, Massachusetts, Michigan, Minnesota, Missouri, Mississippi, New York, North Dakota, Ohio, Oregon, South Dakota, Utah, Washington, Wisconsin, Wyoming)

*Glossiphonia complanata mollissima* Moore, 1898 (Refs 26,40)
Continental Distribution: North America
North American Distribution: USA (Alaska, Bering and Kodiak Islands)

*Glossiphonia heteroclita* (Linnaeus, 1761) (Refs 2,8)
Continental Distribution: North America, Europe, Asia (India), Africa (Ethiopia, Belgian Congo)
North American Distribution: Canada (British Columbia, Newfoundland, Quebec, Ontario, Manitoba, Alberta, Saskatchewan), USA (Connecticut, Indiana, Iowa, Michigan, Mississippi, Ohio, Pennsylvania, Wisconsin)

Genus: *Helobdella* Blanchard, 1896

*Helobdella elongata* (Castle, 1900) (Refs 4,7)
[= *Glossiphonia nepheloidea* Graf, 1899 (nomen nudum)]
Continental Distribution: North America
North American Distribution: Canada (Ontario, Quebec). USA (Florida, Georgia, Indiana, Iowa, Louisiana, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, North Dakota, Ohio, Wisconsin)

*Helobdella fusca* Castle, 1900 (Refs 4,30)
Continental Distribution: North America
North American Distribution: Canada (Alberta, Manitoba, Northwest Territories, Ontario, Quebec, Saskatchewan), Mexico (Federal District, Yucatan), USA (Alaska, California, Colorado, Connecticut, Florida, Indiana, Illinois, Iowa, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Ohio, Oklahoma, Pennsylvania, Vermont, Wisconsin)

*Helobdella lineata* (Verrill, 1874) (Refs 37,57)
[= *papillifera* var. d Verrill, 1874]
Continental Distribution: North America
North American Distribution: Canada (Ontario), USA (Florida, Michigan, Nebraska, Ohio, Wisconsin)

*Helobdella punctatolineata* Moore, 1939 (Ref. 35)
Continental Distribution: North America
North American Distribution: USA (Puerto Rico, Louisiana, Wisconsin)

*Helobdella papillata* (Moore, 1952) (Refs 20,37)
[= *papillifera* var. b Verrill, 1872]
Continental Distribution: North America
North American Distribution: Canada (Ontario), USA (Connecticut, Michigan, Ohio, Wisconsin)

*Helobdella stagnalis* (Linnaeus, 1758) (Refs 2,30)
Continental Distribution: Cosmopolitan
North American Distribution: Canada (generally distributed), Mexico (Guanajuato), Costa Rico, USA (Alaska, Arizona, California, Colorado, Connecticut, Florida, Illinois, Indiana, Iowa, Massachusetts, Michigan, Minnesota, Mississippi, Maine, Montana, Missouri, Nebraska, New York, North Dakota, Ohio, Oregon, Pennsylvania, Utah, Vermont, Wisconsin, Wyoming, New Jersey)

*Helobdella transversa* Sawyer, 1972 (Ref. 46)
Continental Distribution: North America
North American Distribution: USA (Michigan)

Genus: *Marvinmeyeria* Soós, 1969

*Marvinmeyeria lucida* Moore, 1954 (Refs 21,54)
[= *Oculobdella lucida* (Moore)]
Continental Distribution: North America
North American Distribution: Canada (Alberta, British Columbia, Manitoba), USA (Michigan)

Genus: *Oligobdella* Moore, 1918

*Oligobdella biannulata* (Moore, 1900) (Ref. 27)
Continental Distribution: North America
North American Distribution: USA (North Carolina, South Carolina)

Genus: *Placobdella* Blanchard, 1893 (emend. Autrum, 1936)

*Placobdella hollensis* (Whitman, 1892) (Refs 2,30)
Continental Distribution: North America
North American Distribution: Canada (Manitoba, Ontario), USA (Florida, Iowa, Massachusetts, Michigan, Minnesota, Wisconsin)

*Placobdella montifera* Moore, 1906 (Refs 1,29,30)
Continental Distribution: North America
North American Distribution: Canada (British Columbia, Ontario, Saskatchewan), USA (Connecticut, District of Columbia, Indiana, Illinois, Iowa, Kansas, Michigan, Minnesota, Missouri, New York, North Carolina, Ohio, Tennessee, Washington, Wisconsin)

*Placobdella multilineata* Moore, 1953 (Ref. 38)
Continental Distribution: North America
North American Distribution: USA (Florida, District of Columbia, Illinois, Iowa, Michigan, North Carolina, Oklahoma, Texas, Utah)

*Placobdella ornata* (Verrill, 1872) (Refs 30,57)
[= *P. rugosa* Verrill, 1872)]
Continental Distribution: North America
North American Distribution: Canada (Alberta, British Columbia, Manitoba, Nova Scotia, Ontario, Quebec, Saskatchewan), Mexico (scattered questionable reports), USA (California, Colorado, Connecticut, District of Columbia, Florida, Idaho, Illinois, Indiana, Iowa, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Virginia, Washington, Wisconsin)

*Placobdella papillifera* (Verrill, 1872) (Refs 21,37,56)
Continental Distribution: North America
North American Distribution: Canada (Alberta, Manitoba, Northwest Territories), USA (Michigan)

*Placobdella parasitica* (Say, 1824) (Refs 2,30)
Continental Distribution: North America
North American Distribution: Canada (Alberta, Manitoba, Nova Scotia, Saskatchewan, Ontario), Mexico (scattered reports), USA (Arizona, Colorado, Connecticut, Delaware, District of Columbia, Florida, Illinois, Georgia, Indiana, Iowa, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, New York, North Dakota, Ohio, Pennsylvania, South Dakota, Tennessee, Virginia, West Virginia, Wisconsin)

*Placobdella pediculata* Hemingway, 1908 (Refs 1,9,30)
Continental Distribution: North America
North American Distribution: USA (Illinois, Iowa, Maine, Minnesota, Missouri, Oklahoma, Wisconsin)

Genus: *Theromyzon* Philippi, 1867

*Theromyzon maculosum* (Rathke, 1862) (Refs 2,24,54)
[= *T. meyeri* (Livanow, 1902]
Continental Distribution: Holarctic Region, North America
North American Distribution: Canada (Alberta), USA (California, Iowa, Michigan, Minnesota, Montana, North Dakota, Oregon, Pennsylvania)

*Theromyzon rude* (Baird, 1869) (Refs 2,40,54)
[= *T. occidentalis* Verrill, 1874]
Continental Distribution: North America
North American Distribution: Canada (Alberta, British Columbia, Northwest Territories, Saskatchewan), USA (Alaska, Iowa, Colorado, Michigan, Montana, Oregon, South Dakota)

*Theromyzon tessulatum* (O. F. Muller, 1774) (Refs 2,30)
Continental Distribution: Holarctic, Neotropic, North America, Europe, Asia, South America
North American Distribution: Canada (Nova Scotia, Saskatchewan), USA (Alaska, Colorado)

Family Piscicolidae Johnston, 1865

Genus: *Cystobranchus* Diesing, 1859

*Cystobranchus verrilli* Meyer, 1940 (Refs 2,17)
Continental Distribution: North America
North American Distribution: Canada (Ontario, Saskatchewan), USA (Arkansas, Illinois, Iowa, West Virginia)

*Cystobranchus vividus* Verrill, 1872 (Ref. 26)
Continental Distribution: North America
North American Distribution: USA (Massachusetts, North Carolina, Virginia)

*Cystobranchus virginicus* Hoffman, 1964 (Ref. 10)
Continental Distribution: North America
North American Distribution: USA (Virginia)

Genus: *Illinobdella* Meyer, 1940

*Illinobdella alba* Meyer, 1940 (Refs 17,18)
Continental Distribution: North America
North American Distribution: Canada (Ontario), USA (Connecticut, Illinois, Michigan, Minnesota, New York, Tennessee)

*Illinobdella elongata* Meyer, 1940 (Refs 17,18)
Continental Distribution: North America
North American Distribution: Canada (Ontario), USA (Illinois, Michigan, Minnesota)

*Illinobdella richardsoni* Meyer, 1940 (Refs 17,18)
Continental Distribution: North America
North American Distribution: USA (Illinois, California, Kansas, Michigan, Minnesota, Ohio, New York, Tennessee)

Genus: *Myzobdella* Leidy, 1851

*Myzobdella moorei* (Meyer, 1940) (Refs 17,43)
[= *Illinobdella moorei* (Meyer)]
Continental Distribution: North America
North American Distribution: Canada (Alberta, Ontario, Saskatchewan), USA (Alabama, Arkansas, California, Colorado, Connecticut, Florida, Illinois, Iowa, Louisiana, Michigan, Minnesota, New Jersey, New York, Ohio, Oklahoma, Tennessee, Texas)

Genus: *Piscicola* De Blainville, 1818

*Piscicola geometra* (Linnaeus, 1758) (Refs 2,8)
Continental Distribution: Holarctic, Europe, North America, South America
North American Distribution: Canada (Saskatchewan), USA (District of Columbia, Michigan, Minnesota, Wisconsin)

*Piscicola milneri* (Verrill, 1874) (Refs 2,17)
Continental Distribution: North America
North American Distribution: Canada (Alberta, Ontario, British Columbia, Quebec, Saskatchewan), USA (Alaska, California, Maine, Michigan, Minnesota, New York, Wisconsin)

*Piscicola punctata* (Verrill, 1871) (Refs 2,17)
Continental Distribution: North America
North American Distribution: Canada (British Columbia, Ontario, Nova Scotia, Quebec, Saskatchewan), USA (District of Columbia, Illinois, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Montana, New Jersey, New York, North Carolina, Virginia, Wisconsin)

*Piscicola salmositica* Meyer, 1946 (Ref. 19)
Continental Distribution: North America
North American Distribution: Canada (British Columbia), USA (Washington)

*Piscicola zebra* Moore 1898 (Refs 17,26)
Continental Distribution: North America
North American Distribution: Canada (Nova Scotia)

Genus: *Piscicolaria* Whitman, 1889

*Piscicolaria reducta* Meyer, 1940 (Refs 17,18)
Continental Distribution: North America
North American Distribution: Canada (Ontario), USA (Connecticut, Kansas, Illinois, Maine, Michigan, New Jersey)

Order Gnathobdellida Vaillant, 1890

Family Hirudinidae [=Hirudidae]

Genus: *Bdellarogatis* Richardson, 1969

*Bdellarogatis plumbea* (Moore, 1912) (Refs 15,30,45)
[= *Haemopis plumbea* (Moore)]
Continental Distribution: North America
North American Distribution: USA (Iowa, Michigan, Minnesota, Ohio)

Genus: *Mollibdella* Richardson, 1969

*Mollibdella grandis* (Verrill, 1874) (Refs 15,30,45,57)
[= *Haemopis grandis* (Verrill)]
Continental Distribution: North America
North American Distribution: Canada (Alberta, Ontario, Manitoba, New Brunswick, Newfoundland, Prince Edward Island, Quebec, Saskatchewan), USA (Connecticut, Maine, Michigan, Minnesota, New York, Ohio, Virginia, Wisconsin)

Genus: *Percymoorensis* Richardson, 1969

*Percymoorensis kingi* (Mathers, 1954) (Refs 14,45)
[= *Haemopis kingi* (Mathers)]
Continental Distribution: North America
North American Distribution: USA (Iowa, Colorado)

*Percymoorensis lateralis* (Say, 1824) (Refs 2,15,30,45,46)
[= *Haemopis lateralis* (Say)] [= *H. terrestris* Forbes, 1890]
Continental Distribution: North America
North American Distribution: USA (Florida, Illinois, Iowa, Colorado, Kansas, Maine, Michigan, Minnesota, Missouri, North Carolina, Tennessee)

*Percymoorensis lateromaculata* (Mathers, 1963) (Refs 16,45)
[= *Haemopis lateromaculata* (Mathers)]
Continental Distribution: North America
North American Distribution: USA (Iowa, Minnesota)

*Percymoorensis marmoratis* (Say, 1824) (Refs 2,15,30,45)
[= *Haemopis marmoratis* (Say); Moore, 1901]
Continental Distribution: North America
North American Distribution: Canada (generally distributed), USA (Alaska, Colorado, Connecticut, District of Columbia, Illinois, Iowa, Indiana, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Jersey, New Mexico, New York, Ohio, South Carolina, Utah, Virginia, Wisconsin)

Genus: *Hirudo* Linnaeus, 1758

*Hirudo medicinalis* Linnaeus 1758 (Ref. 13)
Continental Distribution: Europe, West Asia, North America (introduced)
North American Distribution: USA (New Jersey?, Pennsylvania?)

Genus: *Macrobdella* Verrill, 1872

*Macrobdella decora* (Say, 1824) (Refs 2,30,45,53)
Continental Distribution: North America
North American Distribution: Canada (Nova Scotia, Alberta, Manitoba, New Brunswick, Ontario, Prince Edward Island, Quebec, Saskatchewan), Mexico (Nuevo León), USA (Colorado, Connecticut, District, of Columbia, Illinois, Iowa, Kansas, Massachusetts, Maryland, Michigan, Minnesota, Maine, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Vermont, Virginia, Wisconsin)

*Macrobdella ditetra* Moore, 1953 (Refs 34,38,53)
Continental Distribution: North America
North American Distribution: USA (Alabama, District of Columbia, Florida, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Texas)

*Macrobdella sestertia* Whitman, 1886 (Refs 2,53,60)
Continental Distribution: North America
North American Distribution: USA (Massachusetts, Louisiana)

Genus: *Philobdella* Verrill, 1874

*Philobdella floridana* (Verrill, 1874) (Refs 37,56)
Continental Distribution: North America
North American Distribution: USA (Florida, Louisiana, North Carolina)

*Philobdella gracilis* Moore, 1901 (Refs 2,28)
Continental Distribution: North America
North American Distribution: USA (Illinois, Louisiana, Michigan, Missouri, Texas)

Order Pharyngobdellida Johnson, 1913

Family Erpobdellidae

Genus: *Dina* R. Blanchard, 1892

*Dina anoculata* Moore, 1898 (Refs 26,47)
Continental Distribution: North America
North American Distribution: Canada (British Columbia), USA (California, Oregon)

*Dina dubia* Moore & Meyer, 1951 (Refs 2,40,47)
Continental Distribution: North America
North American Distribution: Canada (Alberta, Northwest Territories, Saskatchewan), USA (Alaska, Colorado, Iowa, Michigan, Utah)

*Dina lateralis* (Verrill, 1871) (Refs 2,37,49)
Continental Distribution: North America
North American Distribution: Canada (British Columbia, Ontario, Manitoba, Quebec, Saskatchewan), USA (Colorado, Connecticut, Florida, Maine, Michigan, Minnesota, Wisconsin)

*Dina parva* Moore, 1912 (Refs 30,47)
Continental Distribution: North America
North American Distribution: Canada (Alberta, Ontario, Quebec, Saskatchewan), USA (Colorado, California, Indiana, Iowa, Michigan, Minnesota, New York, Virginia, Wisconsin, Wyoming)

*Dina (Mooreobdella) bucera* Moore, 1949 (Refs 36,38,41,56)
Continental Distribution: North America
North American Distribution: USA (Michigan)

*Dina (Mooreobdella) fervida* (Verrill, 1871) (Refs 41,47,56)
Continental Distribution: North America
North American Distribution: Canada (Alberta, Ontario, New Brunswick, Nova Scotia, Prince Edward Island, Quebec, Saskatchewan), USA (Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, North Dakota, Ohio, Pennsylvania)

*Dina (Mooreobdella) microstoma* Moore, 1901 (Refs 2,41,47)
Continental Distribution: North America
North American Distribution: Canada (Ontario), Mexico, USA (California, Colorado, Illinois, Indiana, Iowa, Louisiana, Michigan, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Texas, Wisconsin)

Genus: *Erpobdella* De Blainville, 1818

*Erpobdella punctata* (Leidy, 1870) (Refs 2,30,52)
Continental Distribution: North America
North American Distribution: Canada (generally distributed), Mexico (Federal District, Jalisco, Hidalgo, Yucatán), USA (Alaska, Arizona, California, Colorado, Connecticut, District of Columbia, Georgia, Idaho, Illinois, Indiana, Iowa, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming)

*Erpobdella punctata annulata* Moore, 1922 (Refs 31,52)
Continental Distribution: North America
North American Distribution: Canada (Ontario), USA (Michigan, Oregon, Washington)

*Erpobdella triannulata* Moore, 1908 (Refs 33,52)
Continental Distribution: North America
North American Distribution: Central America (Guatemala, Yucatán), USA (California, North Dakota)

Genus: *Nephelopsis* Verrill, 1872

*Nephelopsis obscura* Verrill, 1872 (Refs 2,30)
Continental Distribution: North America
North American Distribution: Canada (generally distributed), USA (Alaska, Colorado, Idaho, Iowa, Michigan, Minnesota, Mississippi, Montana, New York, North Dakota, Utah, Washington, Wisconsin, Wyoming)

## SECTION III

## KEY TO THE FRESHWATER LEECHES (HIRUDINEA) OF NORTH AMERICA

1 Mouth in form of small pore on anterior sucker from which muscular pharyngeal proboscis may be protruded (Fig. 1a-c); no jaws or denticles. Order Rhynchobdellida ..... 2

Mouth medium to large, occupying entire anterior sucker forming rounded lips (Fig. 1d-f); no protrusible proboscis; teeth either present or absent ..... 3

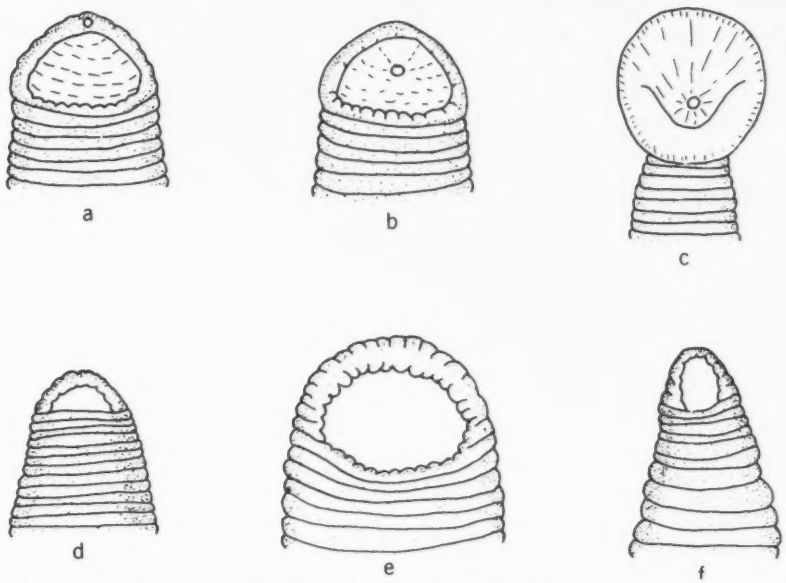


Fig. 1. Ventral views of the anterior suckers to show mouth differences: a- pore on rim of sucker; b- pore within sucker; c- pore near center of sucker; d-f- mouth occupying entire sucker.

2(1) Body flattened, much wider than head (Fig. 2), never cylindrical (except *Helobdella elongata* which is subcylindrical), not divided into distinct anterior (trachelsome) and posterior (urosome) regions; anterior sucker not freely expanded but more or less fused to head; somites 3-annulate; eggs and young attached to ventral surface of adults during their development. Family Glossiphoniidae ..... 4

Body at rest cylindrical, may or may not be divided into distinct narrow (trachelsome) and wider posterior (urosome) regions (especially in contraction) (Fig. 3a-e); anterior sucker expanded, distinctly separate from body (Fig. 3a-e and Fig. 3f, g); 7 or more annuli per somite (except *Piscicolaria reducta* which is 3-annulate); oculiform ocelli or spots sometimes present on posterior sucker (Fig. 3a); eyes 0, 1, or 2 pairs (Fig. 3f, g); pulsatile vesicles present along lateral margins of urosome in *Piscicola* sp. and *Cystobranchus* sp. (Fig. 3a-c); eggs and young never attached to ventral surface of adults during their development. Family Piscicolidae ..... 30

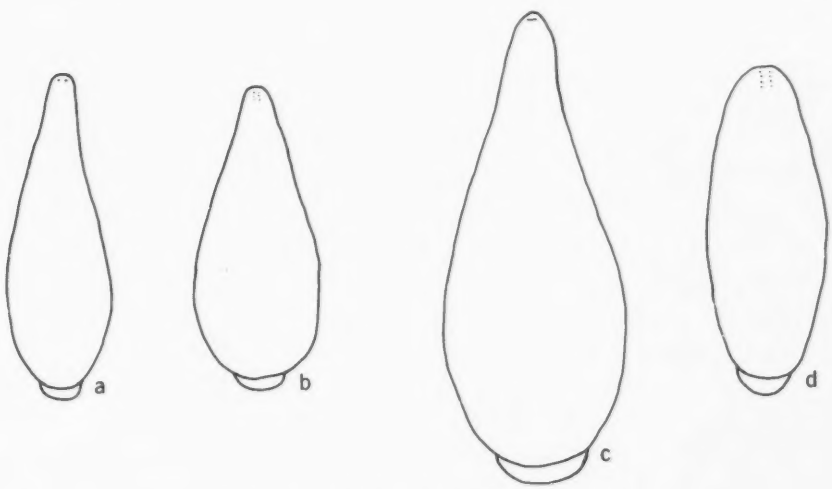


Fig. 2. a-d- General body shape of Glossiphoniidae.

3(1) Eyes 5 pairs, arranged in arch on somites II to IV (Fig. 4a); jaws either present or absent; pharynx short, not extending to clitellum; testes large, arranged in metameric pairs. Order Gnathobdellida. Family Hirudinidae ..... 42

Eyes 3 or 4 pairs in separate labial and buccal groups (Fig. 4b-d) or absent (*Dina anoculata*); no jaws; pharynx extending to XIII, about 1/3 of body length; testes small and numerous in grape-bunch arrangement. Order Pharyngobdellida. Family Erpobdellidae ..... 53

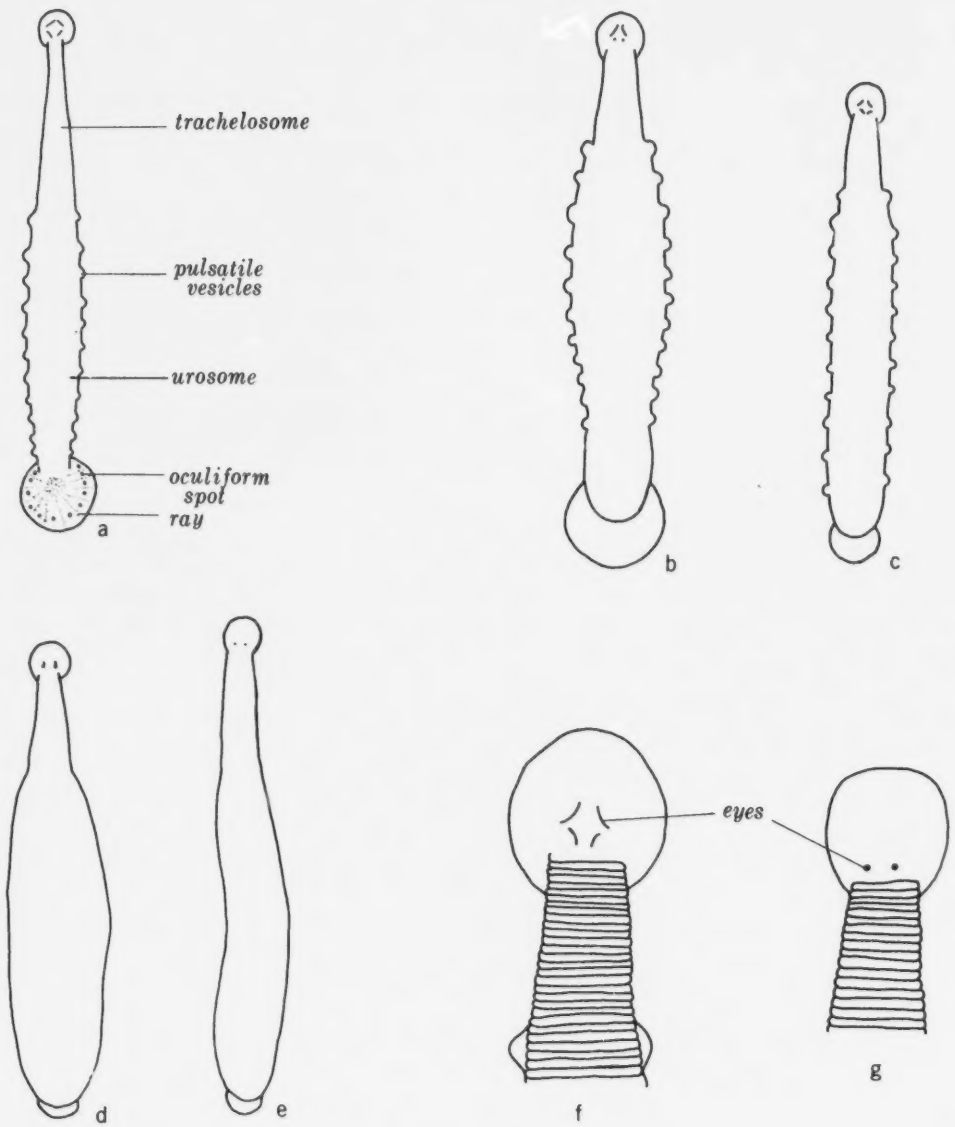


Fig. 3. a-g- General body shape of Piscicolidae in dorsal view.

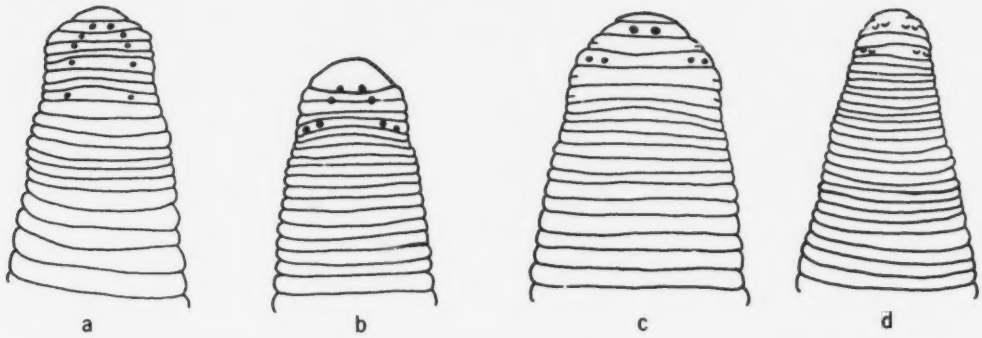


Fig. 4. Dorsal views of arrangement of eyes: a- Hirudinidae; b-d- Erpobdellidae.

4(2) 3 or 4 pairs of eyes (Fig. 5a-c) ..... 10
1 or 2 pairs of eyes (except *Placobdella hollensis* which also has accessory eyes) (Fig. 6a-j) ..... 5

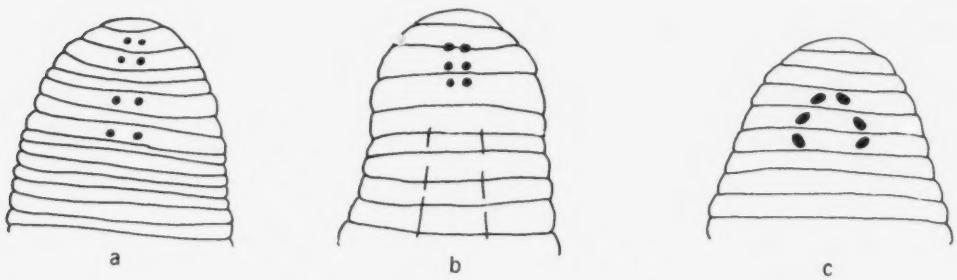


Fig. 5. Dorsal views showing positions of eyes: a- *Theromyzon* sp.; b- *Glossiphonia complanata;* c- *G. heteroclita.*

5(4) Mouth within anterior sucker cavity, clearly not on rim (Fig. 1b) ..... 9
Mouth apical or subapical on rim of anterior sucker (Fig. 1a) .. 6

6(5) Posterior sucker conspicuous with marginal circle of about 30 or 60 glands and retractile papillae, their positions being indicated dorsally by faint radiating ridges (Fig. 7). Genus *Actinobdella* ..... 11
Posterior sucker without marginal circle of glands and retractile papillae ..... 7

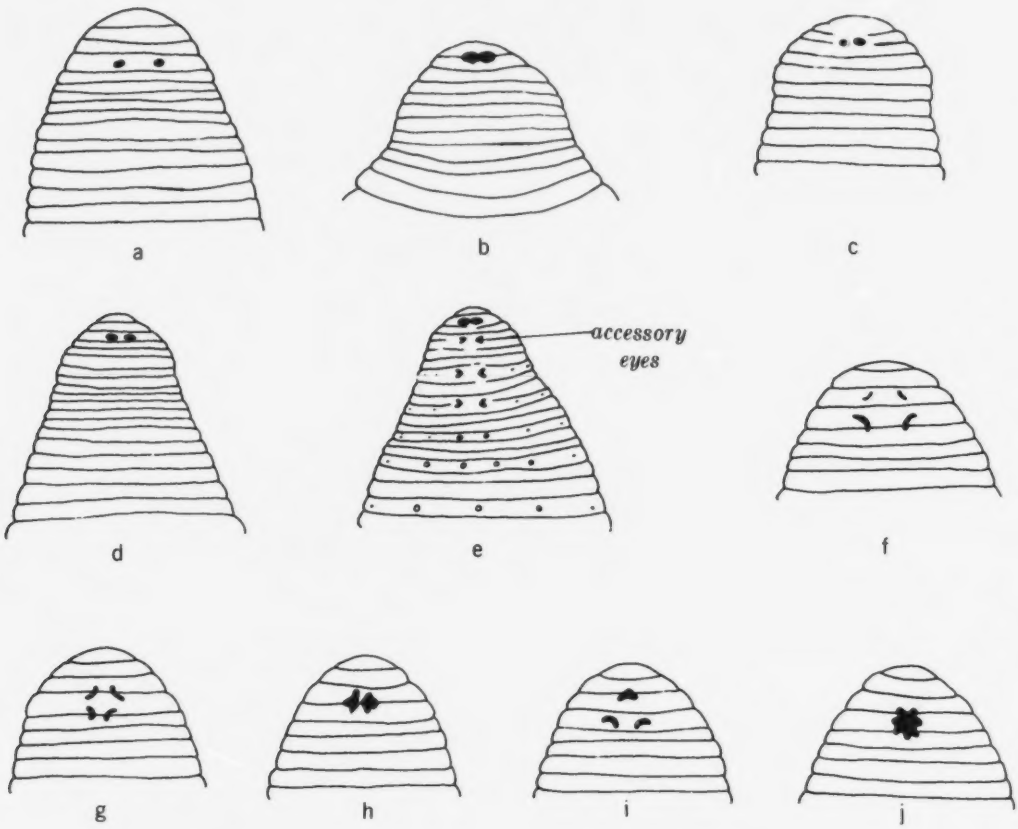


Fig. 6. Dorsal views of eyes: a- well separated; b- fused; c,d- close together; e- fused with accessory eyes; f-j- eyes showing variation (coalescence) in the eye position.

7(6) 1 pair of eyes well separated; male and female gonopores united in common pore; body smooth, not tuberculate, dark streaks between eyes in living and well preserved specimens; dorsum dusky due to nearly uniform distribution of minute blackish chromatophores, dusky diffusion becoming banded towards margins; length 15-22 mm (Fig. 18a): *Marvinmeyeria lucida*

1 pair of eyes fused (Fig. 6b) (except *P. hollensis* which also has several pairs of minute accessory eyes (Fig. 6e) or close together as in *P. montifera* which has eyes almost separated by their diameter (Fig. 6c)); dorsum papillate, tuberculate or smooth ..... 8

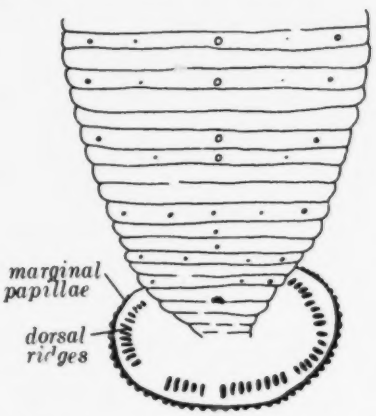


Fig. 7. Dorsal view of posterior sucker of *Actinobdella annectens* showing the marginal papillae and dorsal ridges.

8(7) 1 pair of eyes confluent (fused) or close together; body usually papillate and/or tuberculate. Genus *Placobdella* .. 13
Dorsum smooth, without conspicuous tubercles; translucent, speckled with scattered green and brown pigment cells which give pale olive-green color; large posterior sucker; 1 pair of fused eyes; length 6.3-? mm (Fig. 18b):
*Oligobdella biannulata*

9(5) 1 or 2 pairs of eyes (Fig. 6b or 6f,g); if only 1 pair of eyes present, these may be close together or coalesced (Fig. 6h-j); gonopores separated by 2 annuli. Genus *Batracobdella* .. 19
[see Sawyer (1972) for a new species not in this key]
1 pair of eyes, well separated (Fig. 6a); gonopores separated by 1 annulus. Genus *Helobdella* ..... 21
[see Sawyer (1972) for a new species not in this key]

10(4) 3 pairs of eyes in 2 paramedian rows or in roughly triangular pattern (Fig. 5b,c); body firm. Genus *Glossiphonia* ..... 26
4 pairs of eyes in 2 paramedian lines on somites II-V (Fig. 5a); body after egg laying translucent and soft. Genus *Theromyzon* ..... 28

11(6) Posterior sucker with about 60 dorsal ridges (Fig. 7); dorsal tubercles in 5 longitudinal rows; 6 equal annuli per segment; length 7-11 mm (Fig. 18c): *Actinobdella annectens*
Posterior sucker with about 30 dorsal ridges ..... 12

12(11) Dorsal tubercles prominent in 5 longitudinal rows; posterior sucker with 30 dorsal ridges; 3 annuli per somite; length 7-22 mm (Fig. 18d): *Actinobdella triannulata*
Tubercles confined to mid-dorsal row; about 30 dorsal ridges on posterior sucker; 6 unequal annuli per somite; length 9-21 mm (Fig. 18e): *Actinobdella inequiannulata*

13(8) Anterior somites distinctly widened to form discoid head (Fig. 8); 3 dorsal, prominent, tuberculate keels or ridges; color dull greenish-grey or pale olive-brown; length 9-16 mm (Fig. 18f): *Placobdella montifera*
Without distinct, discoid head ..... 14

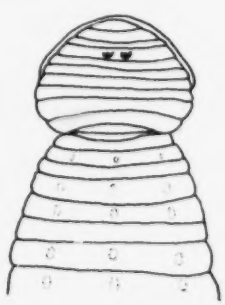

Fig. 8- Dorsal view of anterior end of *P. montifera*, showing the discoid head.

14(13) Anus separated from posterior sucker by slender stalk (peduncle) (Fig. 9); body surface smooth; high dorsally and contractile; 1 pair of eyes close together, hard to detect in adults (small pigment masses at II-IV); color brownish; length 20-35 mm (Fig. 19a): *Placobdella pediculata*
Anus close to posterior sucker, no slender stalk (peduncle).. 15

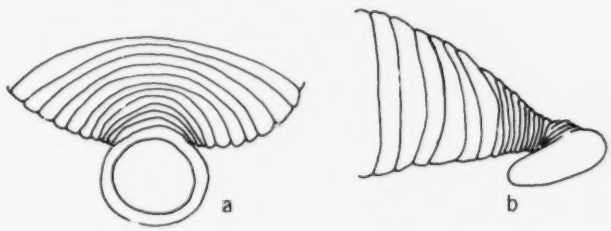


Fig. 9. Posterior sucker and its slender stalk (peduncle) of *P. pediculata*: a- ventral view; b- lateral view.

15(14) Accessory (supplementary) eyes present (Fig. 6e); color light olive-green variegated with brown, pale yellow and colorless areas; length 38-51 mm (Fig. 19b): *Placobdella hollensis*
No accessory eyes ..... 16

16(15) Ventrally striped blue, brown or green (Fig. 10); dorsal tubercles inconspicuous or absent; color variable, usually dark greenish-brown; few papillae, body depressed; length 38-64 mm (Fig. 19c): *Placobdella parasitica*
Not ventrally striped; dorsal tubercles prominent ..... 17

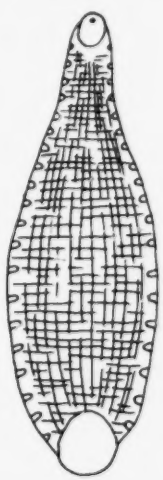

Fig. 10- Ventral view of *P. parasitica* showing stripes.

17(16) Median longitudinal rows of tubercles, especially conspicuous, all tubercles bearing several papillae which gives rough, warty appearance; color pattern of dorsum fine mixture of brown, greens, and yellows with or without median dorsal light or dark stripe interrupted by short brown lines; venter unstriped; length 38-35 mm (Fig. 19d): *Placobdella ornata*
With small more uniform tubercles and papillae ..... 18

18(17) Nearly uniform dark van dyke brown above, slightly paler at head, with much darker brown median dorsal stripe continuous for entire length but fading at head; about 30 dark brown lines beneath surface which remain after preservation; length 48-51 mm (Fig. 19e): *Placobdella multilineata*

5 prominent longitudinal rows of conspicuous, conical, tubercles on dorsum, appearing as whitish spots on coffee brown stripes; ground color, pale or dark brown with faint white or yellow spots; length 15-45 mm (Fig. 19f): *Placobdella papillifera*

19(9) A dense white or yellowish bar on somite VI; dorsal tubercles usually large, acute, pale yellow or brown, deeply pigmented and arranged in median longitudinal dorsal row and 2 other rows halfway to margins; color greenish-brown, flecked with dark spots; length 10-25 mm (Fig. 20a): *Batracobdella phalera*

No dense white or yellowish bar ..... 20

20(19) 2 pairs of eyes (arrangement frequently modified by coalescence of eyes in various ways (Fig. 6f-j)); tubercles absent; color green or brownish-green; length 7-20 mm (Fig. 20b): *Batracobdella paludosa*

1 pair of eyes fused (Fig. 6b); dorsum smooth with 4 rows of white spots; color dark greenish-brown, finely variegated with orange; not ventrally striped; usually thin median dorsal stripe; may or may not have semi-circular orange spots along lateral margins; length 13-25 mm (Fig. 20c): *Batracobdella picta*

21(9) Dorsal nuchal gland (or scute) conspicuous on somite VIII (Fig. 11); no distinct dorsal tubercles; color dusky brown, green or pink; length 9-14 mm (Fig. 20d): *Helobdella stagnalis*

No dorsal nuchal gland (or scute) present ..... 22

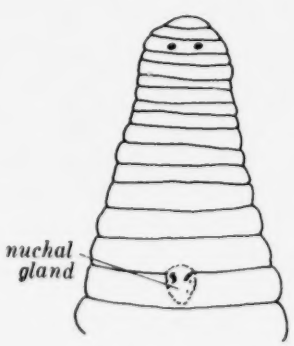


Fig. 11- Dorsal view of *H. stagnalis* showing position of the nuchal gland.

22(21) Body subcylindrical, slender, smoothly rounded; translucent white or colorless; eyes 1 pair, widely separate on somite IV; posterior sucker small and terminal in position; length 9-25 mm (Fig. 20e): *Helobdella elongata*

Body moderately flattened; wider posteriorly (Fig. 2a, b); anterior sucker confluent with body; posterior sucker ventral in position ..... 23

23(22) Dorsum with distinct transverse rows of white spots and prominent longitudinal brown stripes; tubercles absent or nearly so; length 10-20 mm (Fig. 20f): *Helobdella punctatolineata*

Dorsum without distinct transverse rows of white spots ..... 24

24(23) With 5 to 9 longitudinal rows of prominent and numerous tubercles on dorsum, smooth, conical (black or dark brown); general color brown; length 9-14 mm (Fig. 21a): *Helobdella papillata*

Without 5 to 9 rows of prominent and numerous tubercles on dorsum ..... 25

25(24) Tubercles small, smooth and conical; deeply pigmented and often double, many fine longitudinal light and dark brown lines; length 9-14 mm (Fig. 21b): *Helobdella lineata*

Tubercles absent or limited to mid-dorsal line of posterior body somites; color coffee brown or gray with 6 or 7 white spots on every 3rd annulus; length 10-14 mm (Fig. 21c): *Helobdella fusca*

26(10) Body entirely smooth, without papillae, 3 pairs of eyes in rough triangular pattern of groups of 2 each (Fig. 5c); with or without median dorsal brown stripe, but no paired lines; color, uniform amber or whitish; length 6-9 mm (Fig. 21d): *Glossiphonia heteroclita*

Body with papillae and/or tubercles; eyes 3 pairs in paramedian rows (Fig. 5b) but may have coalescence of eyes ... 27

27(26) Body with papillae in 6 longitudinal rows; 1 pair of dark brown stripes broken by pale spots on dorsum and venter; ground color brown, green, or gray; length 14-25 mm (Fig. 21e): *Glossiphonia complanata*

Body with large paramedian knob-like tubercles; dorsum with large pale spots that reduce the dark brown ground color almost to reticulum; paramedian dark stripes, heavy and uninterrupted; ventrum bears no white spots; length 15-25 mm (Fig. 21f): *Glossiphonia complanata mollissima*

28(10) Gonopores separated by 2 annuli; olive-green or brown, nearly transparent, flecked with black spots or conspicuously spotted on dorsum; length 20-26 mm (Fig. 22a): *Theromyzon maculosum*

Gonopores separated by 3 or 4 annuli ..... 29

29(28) Gonopores separated by 3 annuli; color variable with rounded spots of yellow, orange or brown; length 20-30 mm (Fig. 22b): *Theromyzon rude*

Gonopores separated by 4 annuli; color transparent amber or greenish with rounded spots; length 15-30 mm (Fig. 22c): *Theromyzon tessulatum*

30(2) Caudal sucker flattened, as wide or wider than widest part of body; pulsatile vesicles (11 pairs) on margin of body; suckers distinctly set off from body (Fig. 3a-c) ..... 31

Caudal sucker concave, weakly developed and narrower than widest part of body (Fig. 3d, e); pulsatile vesicles absent .. 38

31(30) Pulsatile vesicles small, difficult to see on preserved specimens; body not clearly divided into anterior and posterior regions (Fig. 3a) ..... 32

Pulsatile vesicles large, clearly seen after preservation; body distinctly divided into anterior and posterior regions (Fig. 3b, c) ..... 36

32(31) 8 to 14 ocelli spots on posterior sucker (Fig. 12a-c) ..... 33

Oculiform spots absent from posterior sucker (Fig. 12d); suckers clearly marked off from body; pulsatile vesicles small (11 pairs) on sides of body; no dark rays on caudal sucker; cephalic eyes 2 (or 1) pairs; color translucent, greenish; length 14-16 mm (Fig. 22d): *Piscicola punctata*

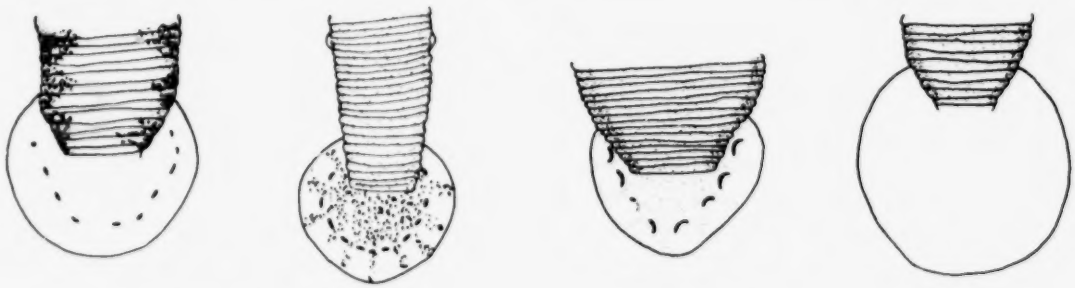


Fig. 12. Dorsal view of posterior suckers: a- oculiform spots only; b- oculiform spots and rays; c- crescent-shaped spots and rays; d- oculiform spots absent.

33(32) Oculiform spots (10-14) on posterior sucker (Fig. 12a-c) ..... 34

Crescent-shaped spots (8-10) on posterior sucker (Fig. 12c); 2 pairs of eyes; body and suckers may or may not be covered with more or less disorderly arrangement of thickly flecked, stellate spots; length 10-31 mm (Fig. 22e): *Piscicola salmositica*

34(33) Posterior sucker with dark rays and 12-14 oculiform spots .... 35
No dark rays, but 10-12 oculiform ocelli on posterior sucker (Fig. 12a); color in mid-region of body yellowish with brownish stellate flecks, disposed roughly in 5 longitudinal rows; dorsally these flecks from slightly acute (triangular) angle and spread out laterally; length 16-24 mm (Fig. 22f): *Piscicola milneri*

35(34) 12-14 oculiform ocelli on posterior sucker separated by dark rays (Fig. 12b); color greenish, yellowish, or brownish, usually finely sprinkled with minute black or brown cells, disposed more or less regularly in longitudinal rows; length 20-30 mm (Fig. 23a): *Piscicola geometra*
Posterior sucker with 14 dark, irregular brown rays each terminated by an oculiform spot; 2 pairs of eyes, anterior eyes larger; length 19-? mm (Fig. 23b): *Piscicola zebra*

36(31) Segments in middle of body with 6 annuli; 2 regions of body sharply distinguished; lateral vesicles large; color of dorsum dusky brown or purplish-brown, finely speckled with stellate points of darker brown, and with irregular rows of conspicuous, small, rounded, opaque, white spots along upper surface of dorsum; length 15-? mm (Fig. 23c): *Cystobranchus vividus*
Segments in middle of body with 7 annuli ..... 37

37(36) Gonopores separated by 2 annuli; pulsatile vesicles large; void of pigment cells or with brownish-black spots profusely distributed over entire surface of body and suckers; caudal sucker very large; length 10-30 mm (Fig. 23d): *Cystobranchus verrilli*
Gonopores separated by 1 or 2 annuli; pulsatile vesicles large; posterior sucker with about 10 oculiform spots and only slightly greater in diameter than anterior sucker; length 9-15 mm (Fig. 23e): *Cystobranchus virginicus*

38(30) Body divided into narrow anterior region and wider posterior region (Fig. 3d); eyes 1 pair; no color or with brownish-black stellate pigment cells; gonopores separated by 8 annuli; length 24-26 mm (Fig. 23f): *Myzobdella moorei*
Body not divided into 2 regions (Fig. 3e) .....39

39(38) Anterior sucker spatulate or bell-shaped (Fig. 3g) ..... 40
Anterior sucker weakly developed, not spatulate or bell-shaped ..... 41

40(39) Eyes present or absent, if present located on posterior half of spatulate oral sucker; anus 15 annuli from posterior sucker; color greenish, body wall usually devoid of pigment; length 15-20 mm (Fig. 24a): *Illinobdella richardsoni*

Eyes 1 pair, present on posterior half of somewhat spatulate or bell-shaped sucker; sides of body nearly parallel; only slight decrease in width anteriorly, practically none posteriorly (this species is readily recognised by its proportions); anus 10 annuli or less from posterior sucker; length 25-30 mm (Fig. 24b): *Illinobdella elongata*

41(39) Body thin, devoid of pigment; eyes 1 pair on posterior half of weakly developed anterior sucker; gonopores separated by 8 annuli; length 9-10 mm (Fig. 24c): *Illinobdella alba*

Color consists of brown-black pigments arranged in 6 longitudinal rows, especially 2 most dorsal rows; eyes 1 pair in posterior region of oral sucker; somite 3-annulate; length 6-8 mm (Fig. 24d): *Piscicolaria reducta*

42(3) Copulatory glands present behind gonopores on ventral surface (Fig. 13) ..... 43

Copulatory glands absent ..... 45

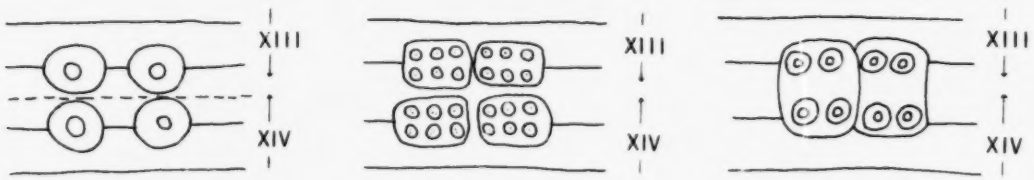


Fig. 13. Diagrams of the arrangement of copulatory gland pores: a- *Macrobdella decora*; b- *M. sestertia*; c- *M. ditetra*. (After Moore).

43(42) About 21 bright red or orange spots in mid-dorsal line ..... 44

Red spots absent from mid-dorsal line; 8 copulatory gland pores (Fig. 13c); 2 annuli between gonopores; about 50 teeth per jaw; color of dorsum drab brown with darker median field 1/3 body width, venter yellowish with some or no black blotches; length 100-150 mm (Fig. 24e): *Macrobdella ditetra*

44(43) 4 copulatory gland pores (Fig. 13a); 5 annuli between gonopores; color of dorsum green with median row of red or orange spots, lateral black spots; ventral surface red or orange; about 65 teeth per jaw; length 110-150 mm (Fig. 24f): *Macrobdella decora*

24 copulatory gland pores (Fig. 13b); 2 1/2 annuli between gonopores; color of ventral side bright reddish brown with few scattered flecks of black, dorsum olive-green with median row of orange or red spots, lateral black flecks; length 50-100 mm (Fig. 25a): *Macrobdella sestertia*

45(42) Dorsum with 1 or more colored stripes ..... 46
Dorsum without colored stripes ..... 50

46(45) Dorsal surface with single median stripe ..... 47
Dorsum with pair of longitudinal red stripes; color pattern variable, greenish background and pattern of irregular black markings near lateral margins, ventral surface black with white and gray markings; jaws with 35-100 teeth; length 30-150 mm (Fig. 25b): *Hirudo medicinalis*

47(46) Dorsal surface with median black stripe ..... 48
Dorsal surface with another colored median stripe ..... 49

48(47) With distinct median dorsal black stripe; ground color uniform brownish-green to olive, with scattered black and yellowish-orange blotches (usually more black than yellow-orange); margins conspicuously mottled with yellowish-orange blotches forming broken longitudinal lines; ventrally darker, plumbeous and uniform, occasional yellowish-orange blotches; teeth 9-12 pairs; length 60-90 mm; young with metameric bands (Fig. 25c): *Percymoorensis kingi*

Dorsal surface with median black stripe and orange marginal stripes, uniformly gray, ventrally lighter, few or no dark blotches; jaws with 20-25 pairs of teeth; length 150-200 mm (Fig. 25d): *Percymoorensis lateralis*

49(47) With dark brown median stripe, lateral margins with irregular black stripes sometimes broken but no discrete spots; 20 teeth per jaw; length 40-85 mm (Fig. 25e): *Philobdella floridana*

With light yellow median dorsal stripe and dorsolateral brownish-black irregular spots; about 40 (35-48) teeth per jaw; length 40-85 mm (Fig. 25f): *Philobdella gracilis*

50(45) Jaws absent or vestigial (Fig. 14a) ..... 51
Jaws very small and retractable into narrow-mouthed tubular pits, 10-16 coarse pairs of teeth per jaw (Fig. 14b, c) ... 52

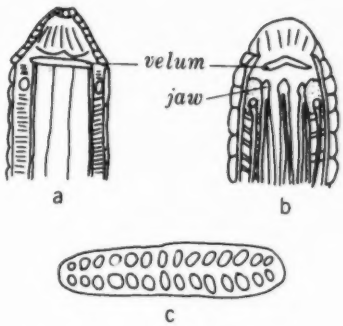


Fig. 14. Ventral view of the dissection of the mouth and buccal cavity and cross section of teeth: a- *Mollibdella grandis* showing velum and absence of jaws; b- *Percymoorensis marmoratis* showing velum, relative size of jaws; c- distichrodont arrangement of teeth.

51(50) Dorsum grayish in color with few or no blotches, with reddish or orange band along margins; lower surface of velum finely and closely papillate; gonopores in middle of annuli separated by 5 annuli; pharynx with 15 internal ridges; length 150-200 mm (Fig. 26a): *Bdellarogatis plumbea*

Color highly variable, but usually shades of dull green, gray, or plain, always more or less blotched with black; lower surface of velum smooth (Fig. 14a); pharynx with 12 internal ridges; gonopores in furrows, separated by 5 annuli; length 175-300 mm (Fig. 26b): *Mollibdella grandis*

52(50) Jaws with 10-14 pairs of teeth (commonly 11-12); color olive-green dorsally, heavily blotched with few scattered yellow blotches, ventrally darker, uniform gray, few indistinct black or yellowish blotches; caudal sucker large, about 3/4 width of body, discoid, broadly attached by very short pedicel which tapers to direct attachment to somite XXVII; length 50-85 mm (Fig. 26c): *Percymoorensis lateromaculata*

Jaws with 12-16 pairs of teeth (Fig. 14b, c); color usually blotched and more or less thickly flecked with black-brown and yellow-gray; posterior sucker about 1/2 width of body; length 75-100 mm (Fig. 26b): *Percymoorensis marmoratis*

53(3) Somites 5-annulate (b1, b2, a2, b5, and b6, with b6 never distinctly subdivided all annuli being equal in length) (Fig. 15b); dorsum usually with 2 or 4 longitudinal stripes of brown of black spots but may be heavily black barred form or pigmentless. Genus *Erpobdella* ..... 55

Somites 6- or 7-annulate, annuli differing in length with b6 either subdivided or longer than others, in any group of 6 consecutive annuli at least 1 is either narrower or wider than rest, narrower or wider annulus occurring regularly along body (Fig. 15a); eyes 3 or 4 pairs..... 54

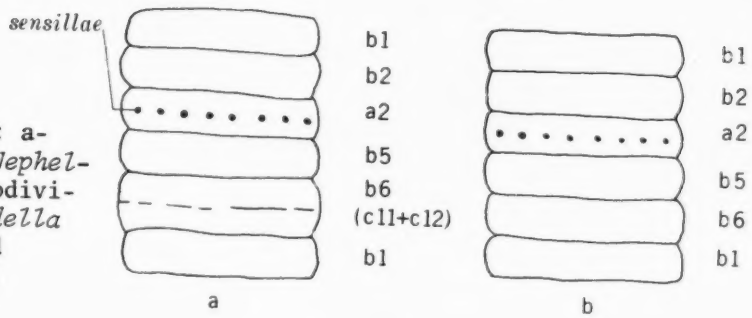


Fig. 15. Annulation: a- *Dina (Mooreobdella)-Nephelopsis* showing the subdivision of b6; b- *Erpobdella* showing the undivided nature of annulus b6.

54(53) Anterior and posterior 2 pairs of eyes arranged in parallel (Fig. 4d); atrial cornua spirally coiled like ram's horn (Fig. 16a, b); coloration gray, spotted with black blotches or plain; length 26-40 mm (Fig. 26e):
*Nephelopsis obscura*

Atrial cornua simply curved (Fig. 17a-e); 3 or 4 pairs of eyes (except *D. anoculata*); dorsum with spots, longitudinal stripes, or none. Genus *Dina*: Subgenus *Mooreobdella* .... 57

55(53) 2 annuli between gonopores ..... 56

3 annuli between gonopores; color, olive or dull green, marked with 4 longitudinal stripes composed of numerous small black spots with pale centers in which sensory papillae are situated, ventral surface and lateral margins plain gray or ashy, unpigmented; 3 pairs of eyes, 1st pair much larger on somite II; atrial cornua simply curved, ejaculatory duct with long preatrial loop (Fig. 17a); length 25-30 mm (Fig. 27b):
*Erpobdella triannulata*

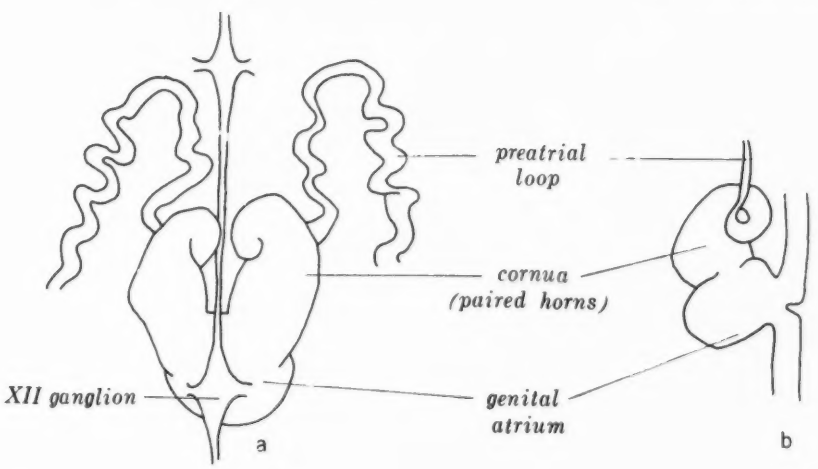


Fig. 16. Male genital atrium of *N. obscura*: a- dorsal view; b- lateral view. (After Moore).

56(55) 2 or 4 rows of black spots on dorsum or plain with few black areas; atrial cornua simply curved, ejaculatory duct with long preatrial loop (Fig. 17a); 3 pairs of eyes, 1st pair smallest; length 80-100 mm (Fig. 26f): *Erpobdella punctata*
Same as above except heavily black barred form (Fig. 27a): *Erpobdella punctata annulata*

57(54) Eyes 3 or 4 pairs (Fig. 4b, c) ..... 58
Eyes absent; gonopores in furrows separated by 2 annuli; longitudinal stripes down body; ejaculatory duct with long preatrial loop; length 10-15 mm (Fig. 27c): *Dina anoculata*

58(57) 3 pairs of eyes (except sometimes 4 pairs in *D. (M.) fervida*) (Fig. 4c) ..... 59
4 pairs of eyes (Fig. 4b) ..... 62

59(58) Gonopores separated by 2 annuli ..... 60
Gonopores separated by 2 1/2 to 4 annuli ..... 61

60(59) Atrium globular with prominent horns longer than its diameter (Fig. 17b); eyes (3 or 4 pairs); gonopores separated by 2 annuli normally on rings; posterior sucker large; ejaculatory duct without long preatrial loop; color varying, either lacking pigment entirely, or pale red with darker clouding or with 2 narrow or broad, dark longitudinal stripes extending over body, including always 1 light median stripe; length 25-51 mm (Fig. 27d):*Dina (Mooreobdella) fervida*
Atrium globoid as above (Fig. 17c); ejaculatory duct without long preatrial loop; gonopores separated by 2 annuli on rings or in furrows; length 25-32 mm (Fig. 27e): *Dina (M.) bucera*

61(59) Gonopores separated by 3 annuli, usually in furrows; atrium ellipsoidal, wider than long, with horns shorter than diameter of median atrium (Fig. 17d); ejaculatory duct without long preatrial loop; eyes 3 pairs; color reddish from blood showing through or light yellowish or light grayish or unpigmented; length 30-50 mm (Fig. 27f): *Dina (M.) microstoma*
Gonopores separated by 3 1/2 annuli; 2 rows of black spots on dorsum; atrial cornua short, merely curved (Fig. 17e); ejaculatory duct with preatrial loop; eyes 3 pairs; color liver or reddish in life; length 25-50 mm (Fig. 28a): *Dina lateralis*

62(58) With few dark spots or no pigment; gonopores usually separated by 3 1/2 (sometimes 2 1/2 or 3) annuli, male on annuli, rarely in furrow, female in furrow; ejaculatory duact with preatrial loop; length 25-29 mm (Fig. 28b): *Dina parva*
With dark brown or blackish median dorsal stripe visible in cephalic half, fading out posteriorly, usually heavily blotched; gonopores usually separated by 3 1/2 (sometimes 4) annuli, male on annuli, female in furrow; ejaculatory duct with preatrial loop; length 25-41 mm (Fig. 28c): *Dina dubia*

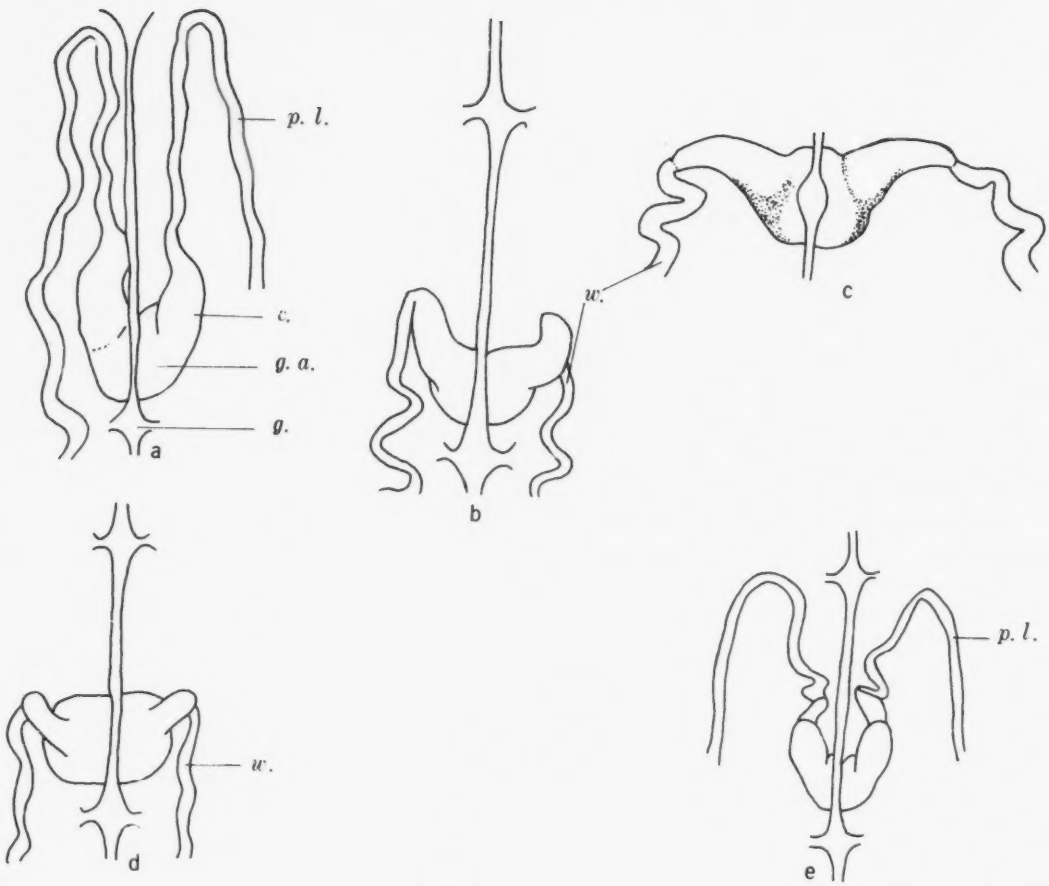


Fig 17. Dorsal view of dissected male genital atrium and ejaculatory duct with or without long preatrial loop: a- *E. punctata;* b- *D. (M.) fervida;* c- *D. (M.) bucera;* d- *D. (M.) microstoma;* e- *D. lateralis.* (After Moore)

c- cornua (paired horns); g- XII, twelfth ganglion; g.a.- genital atrium; p.l. preatrial loop; w- without preatrial loop.

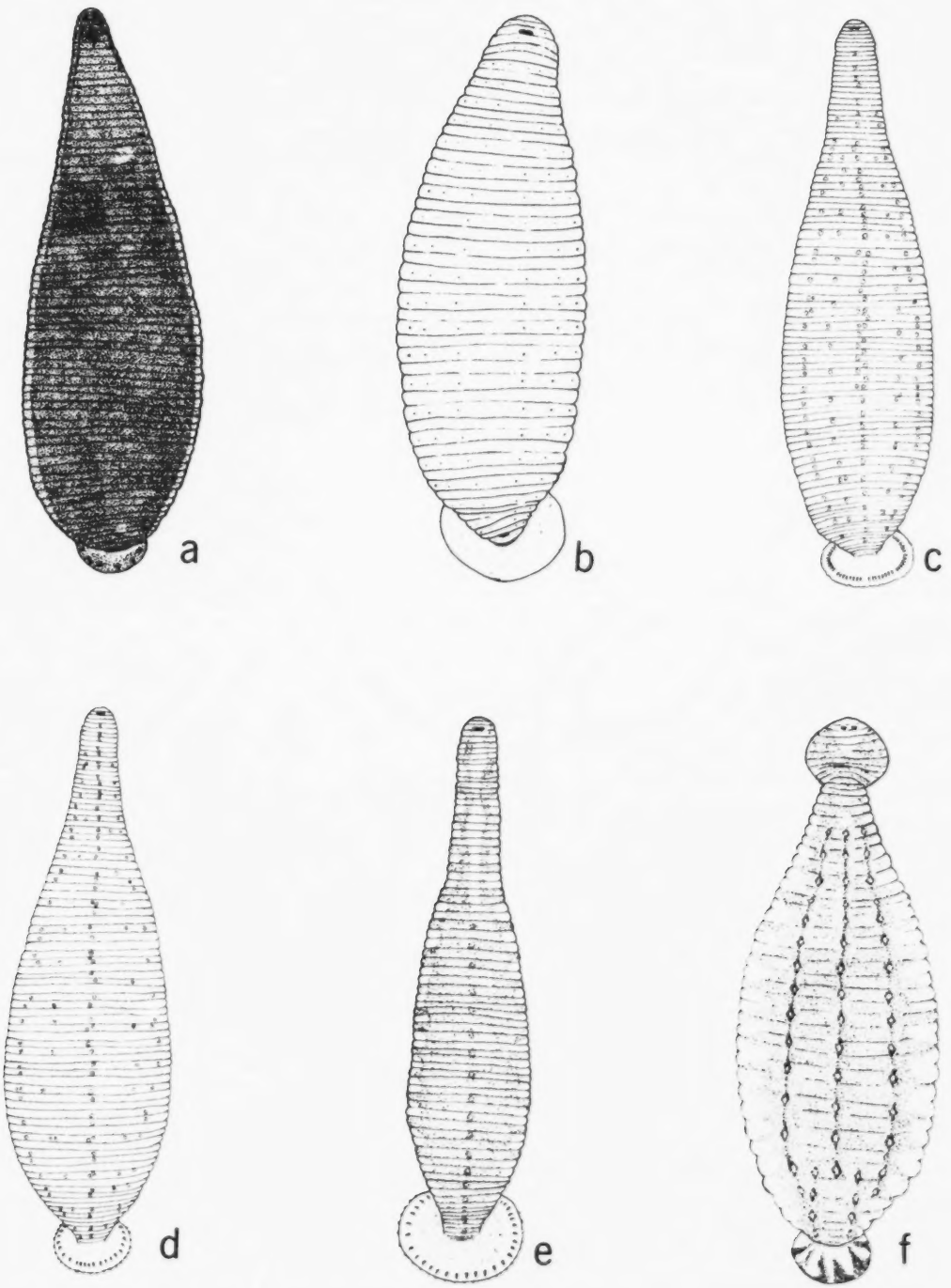


Fig. 18. a- *Marvinmeyeria lucida;* b- *Oligobdella biannulata;* c- *Actinobdella annectens;* d- *A. triannulata;* e- *A. inequiannulata;* f- *Placobdella montifera.*

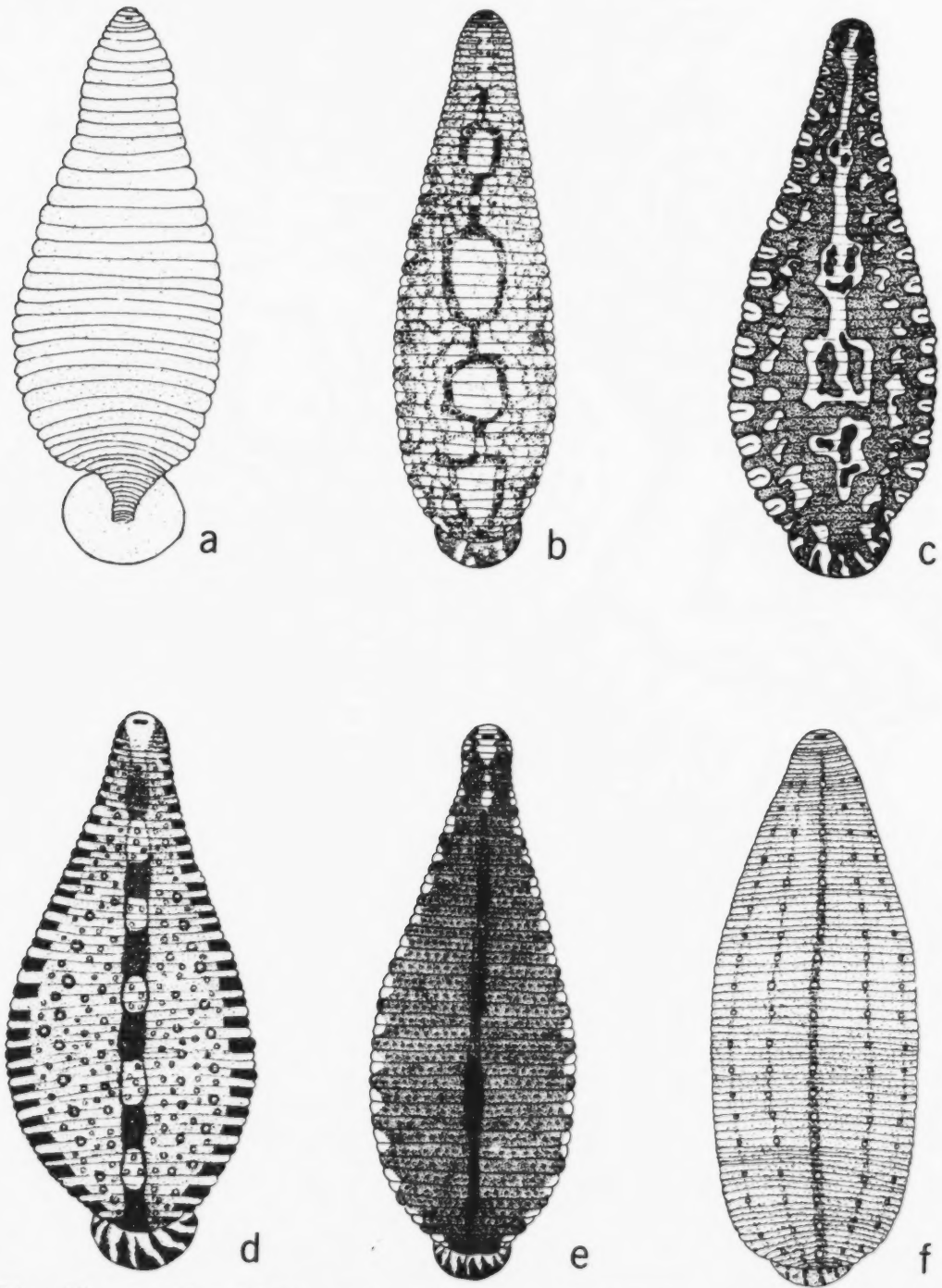


Fig. 19. a- *Placobdella pediculata*; b- *P. hollensis*; c- *P. parasitica*; d- *P. ornata*; e- *P. multilineata*; f- *P. papillifera*.

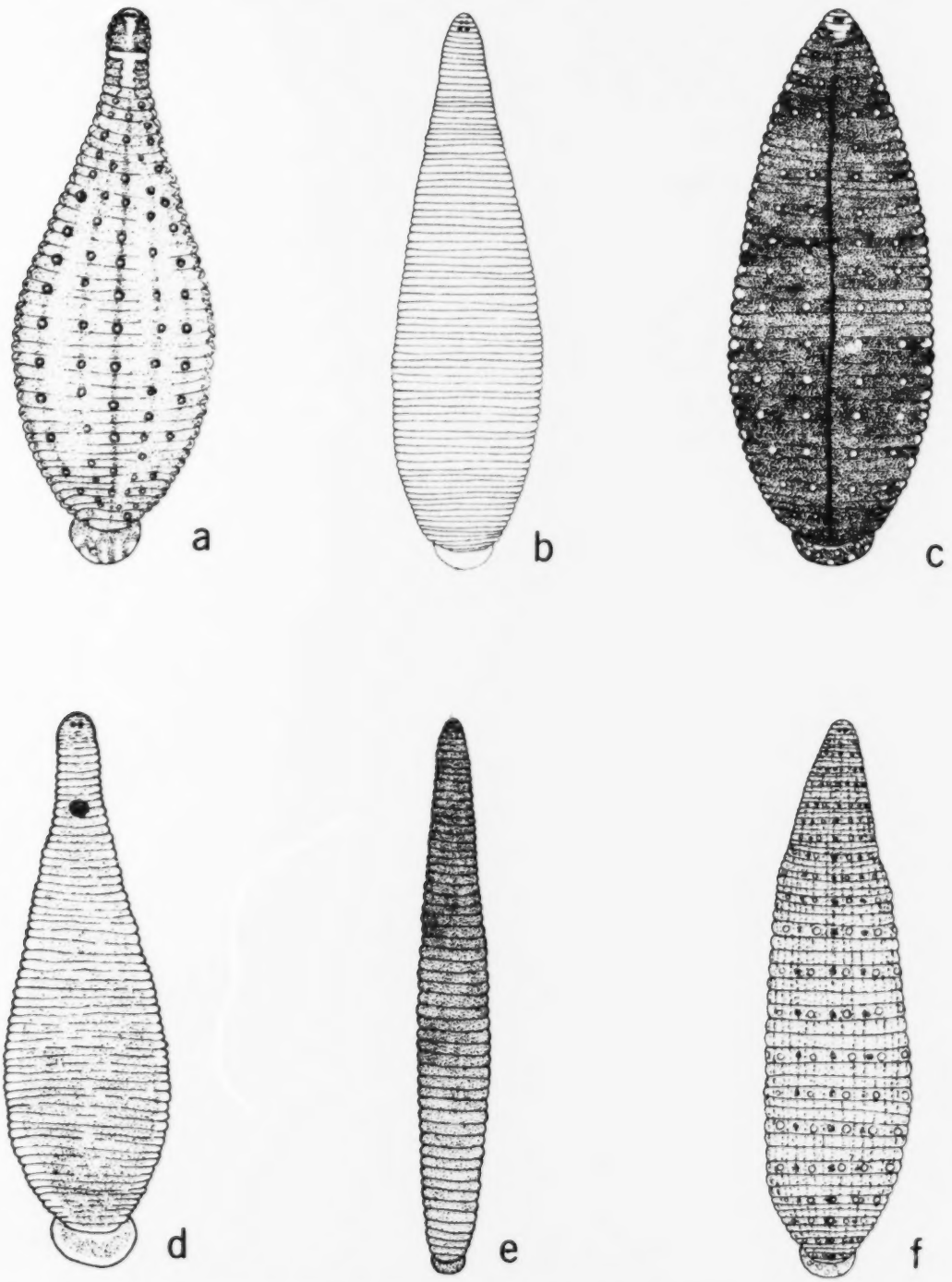


Fig. 20. a- *Batracobdella phalera*; b- *B. paludosa*; c- *B. picta*; d- *Helobdella stagnalis*; e- *H. elongata*; f- *H. punctatolineata*.

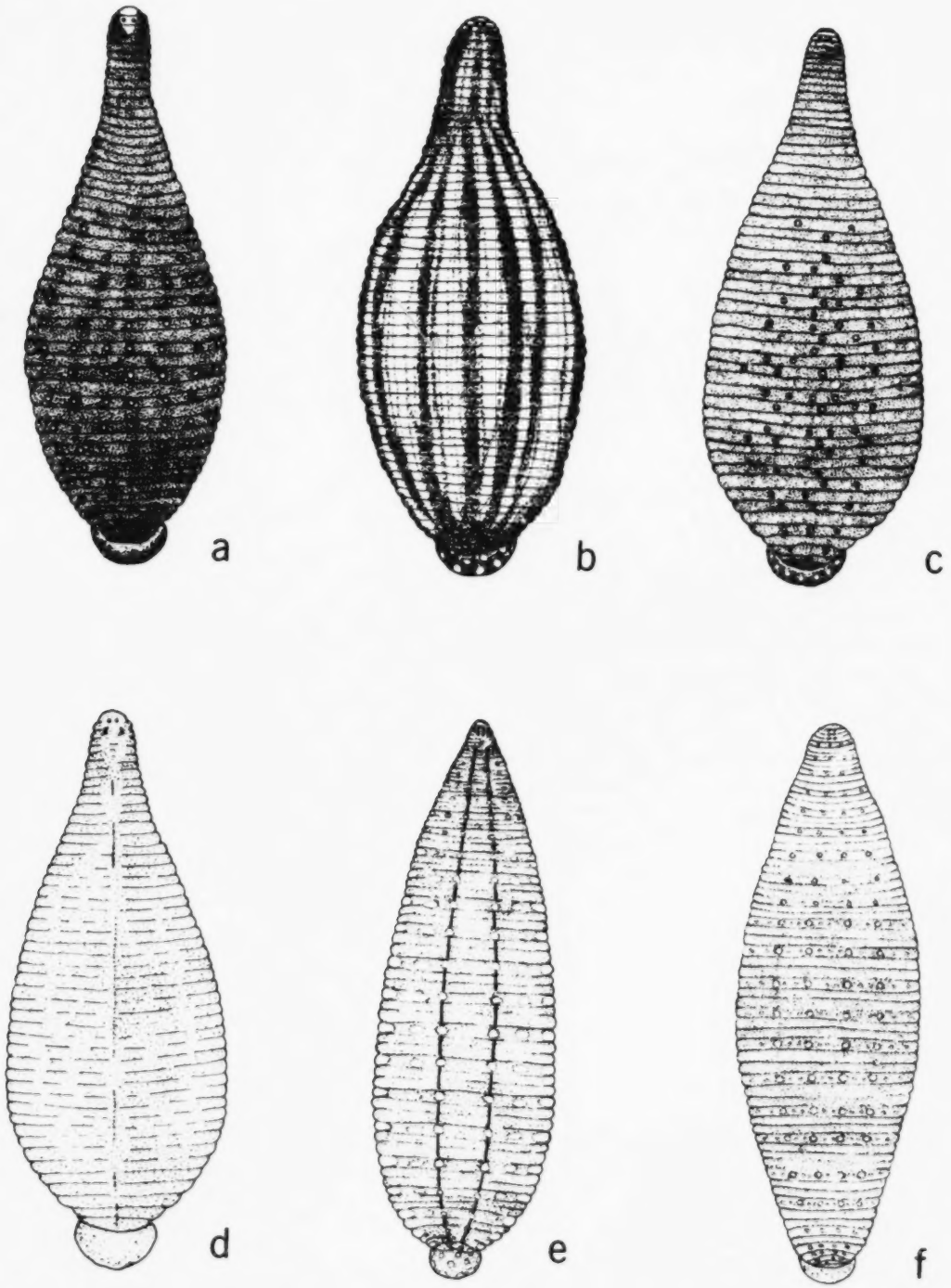


Fig. 21. a- *Helobdella papillata;* b- *H. lineata;* c- *H. fusca;* d- *Glossiphonia heteroclita;* e- *G. complanata;* f- *G. complanata mollissima.*

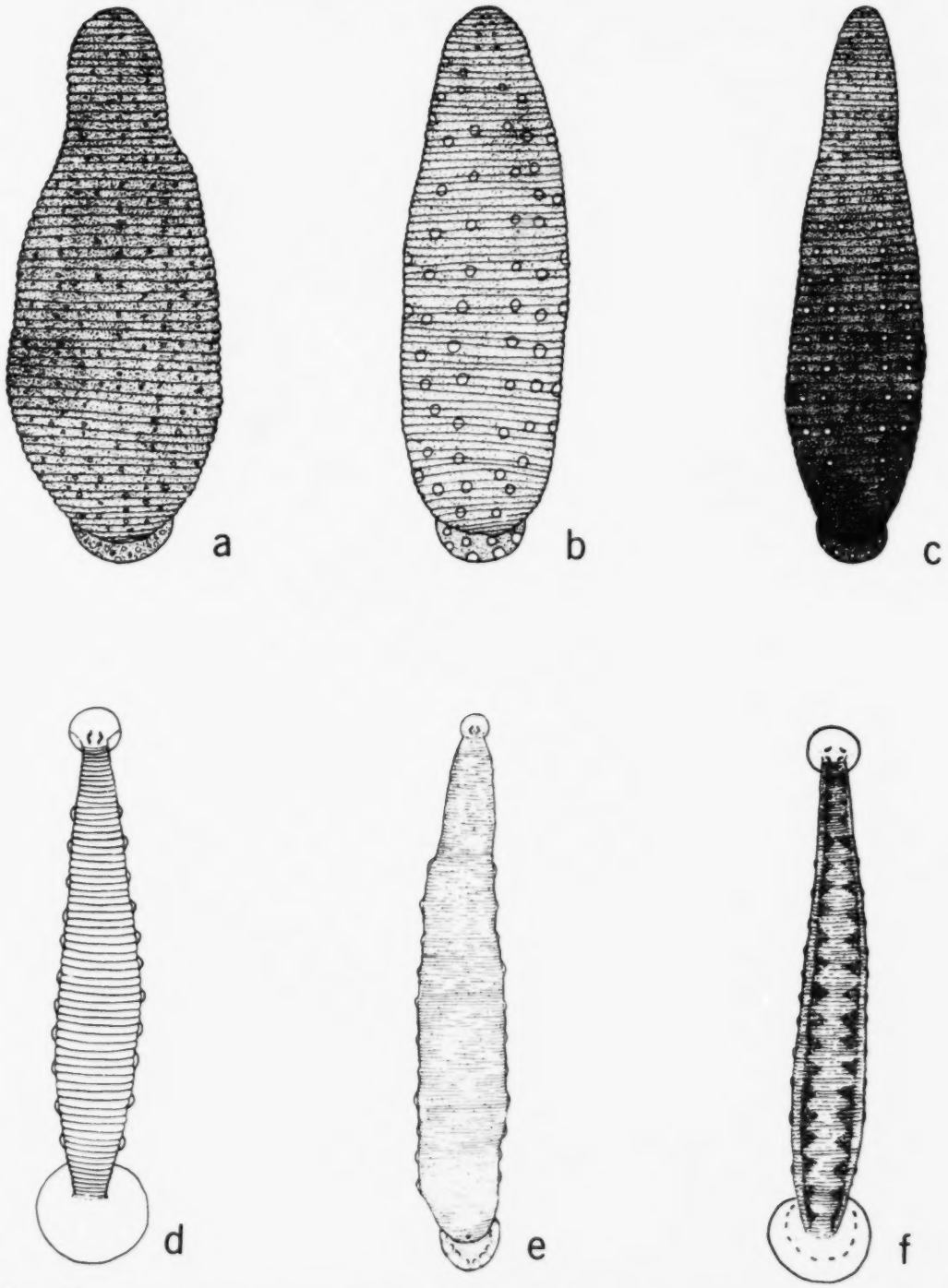


Fig. 22. a- *Theromyzon maculosum*; b- *T. rude*; c- *T. tessulatum*; d- *Piscicola punctata*; e- *P. salmositica*; f- *P. milneri*.

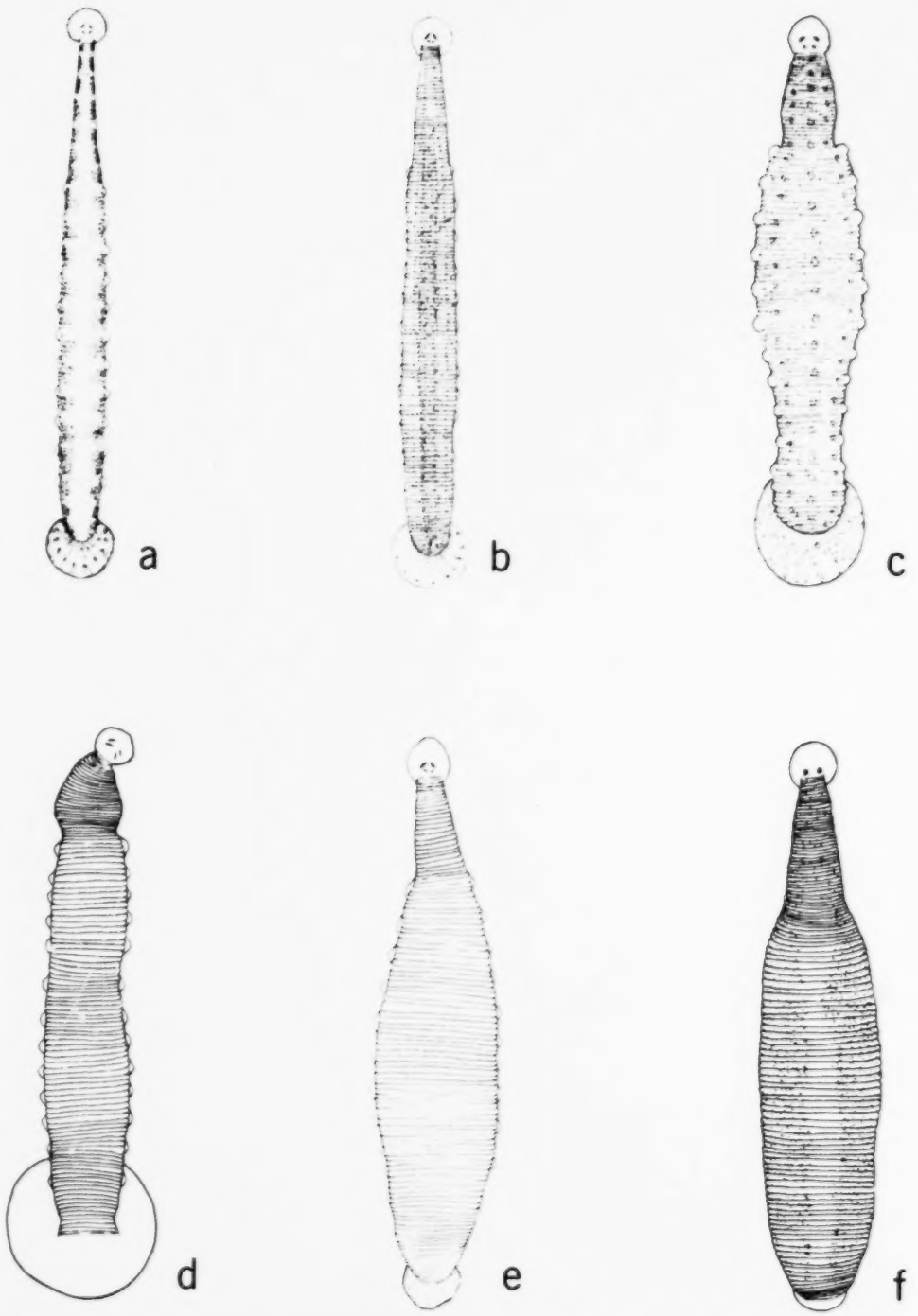


Fig. 23. a- *Piscicola geometra;* b- *P. zebra;* c- *Cystobranchus vividus;* d- *C. verrilli;* e- *C. virginicus;* f- *Myzobdella moorei.*

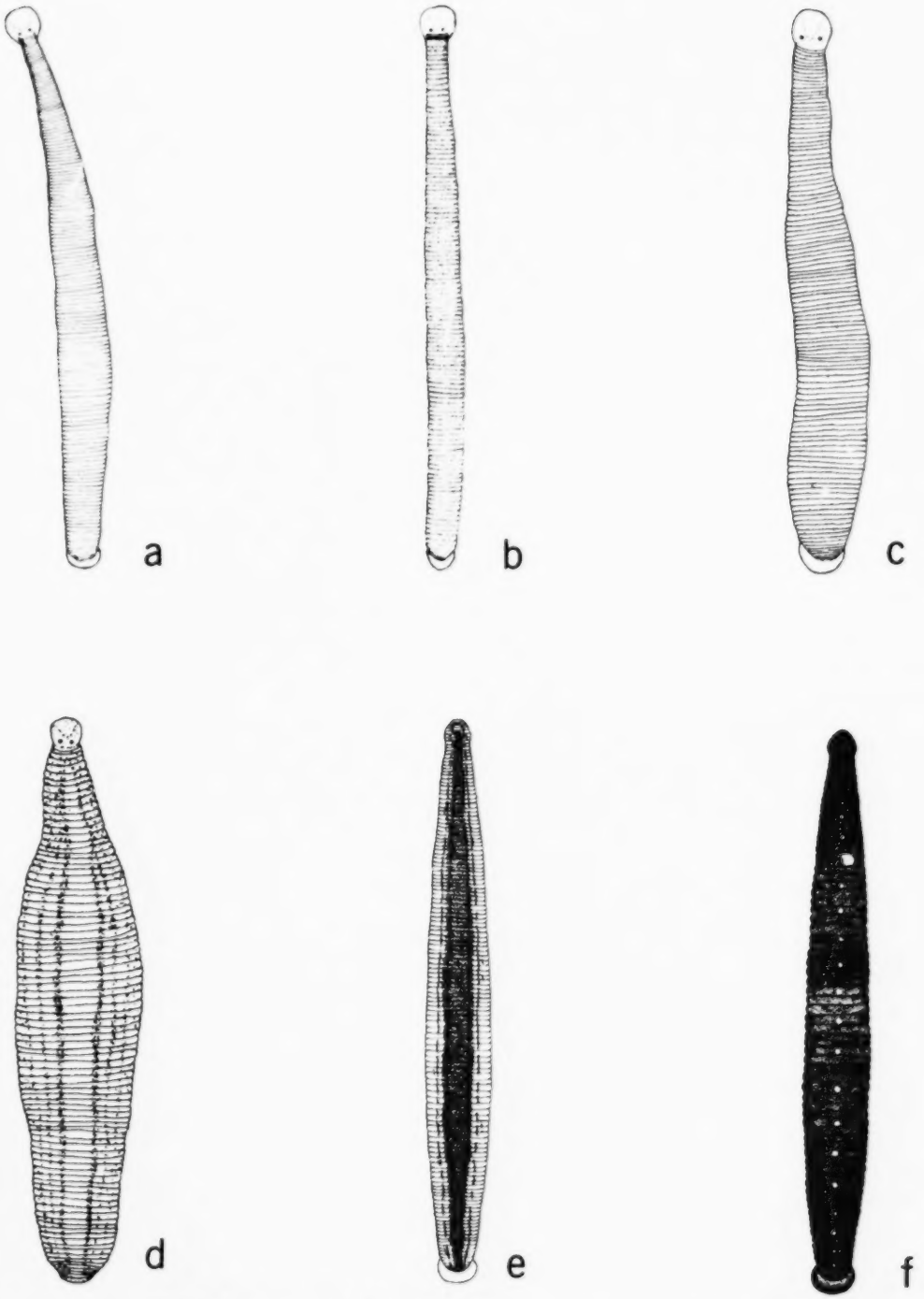


Fig. 24. a- *Illinobdella richardsoni;* b- *I. elongata;* c- *I. alba;* d- *Piscicolaria reducta;* e- *Macrobdella ditetra;* f- *M. decora.*

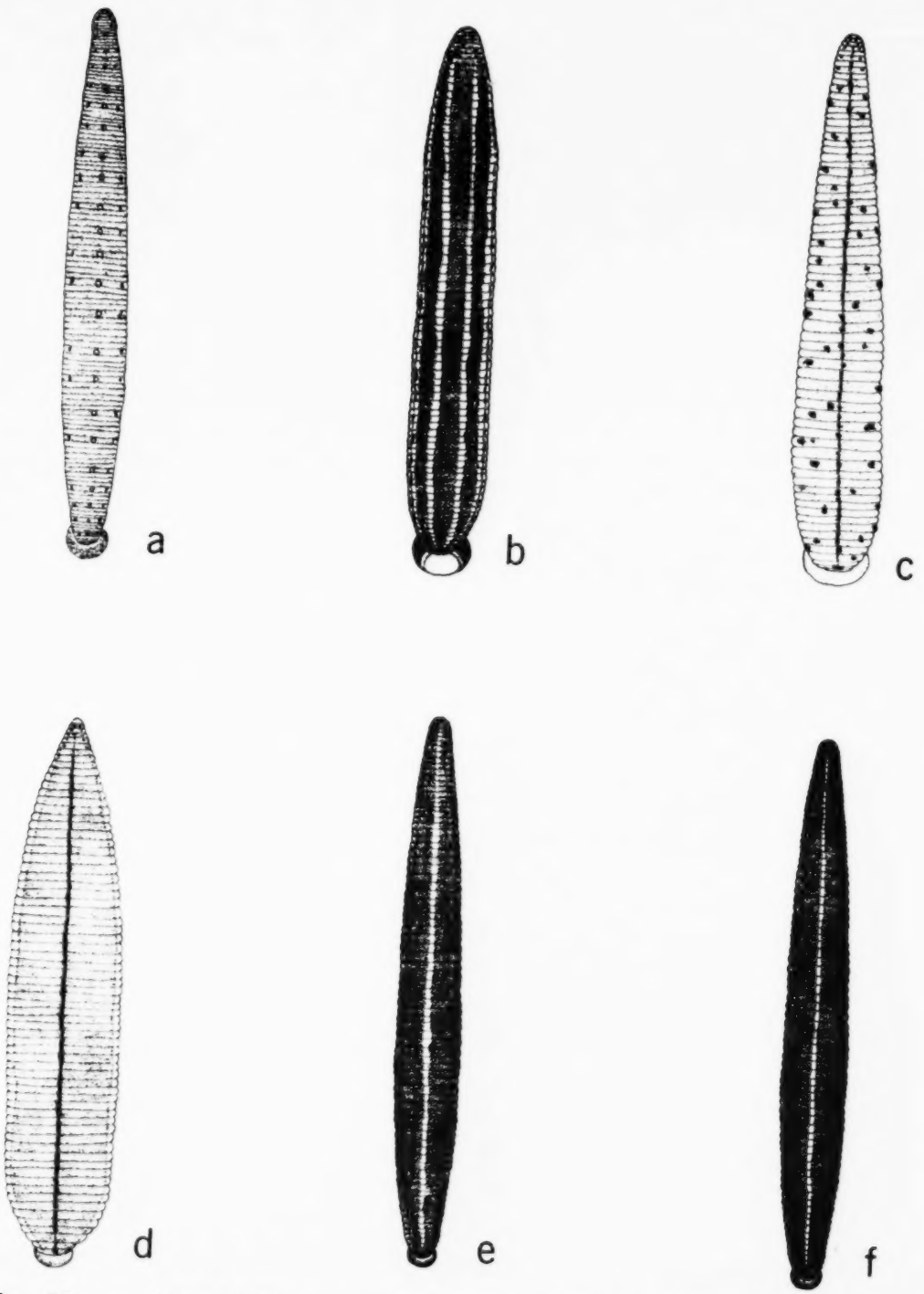


Fig. 25. a- *Macrobdella sestertia*; b- *Hirudo medicinalis*; c- *Percymoorensis kingi*; d- *P. lateralis*; e- *Philobdella floridana*; f- *P. gracilis*.

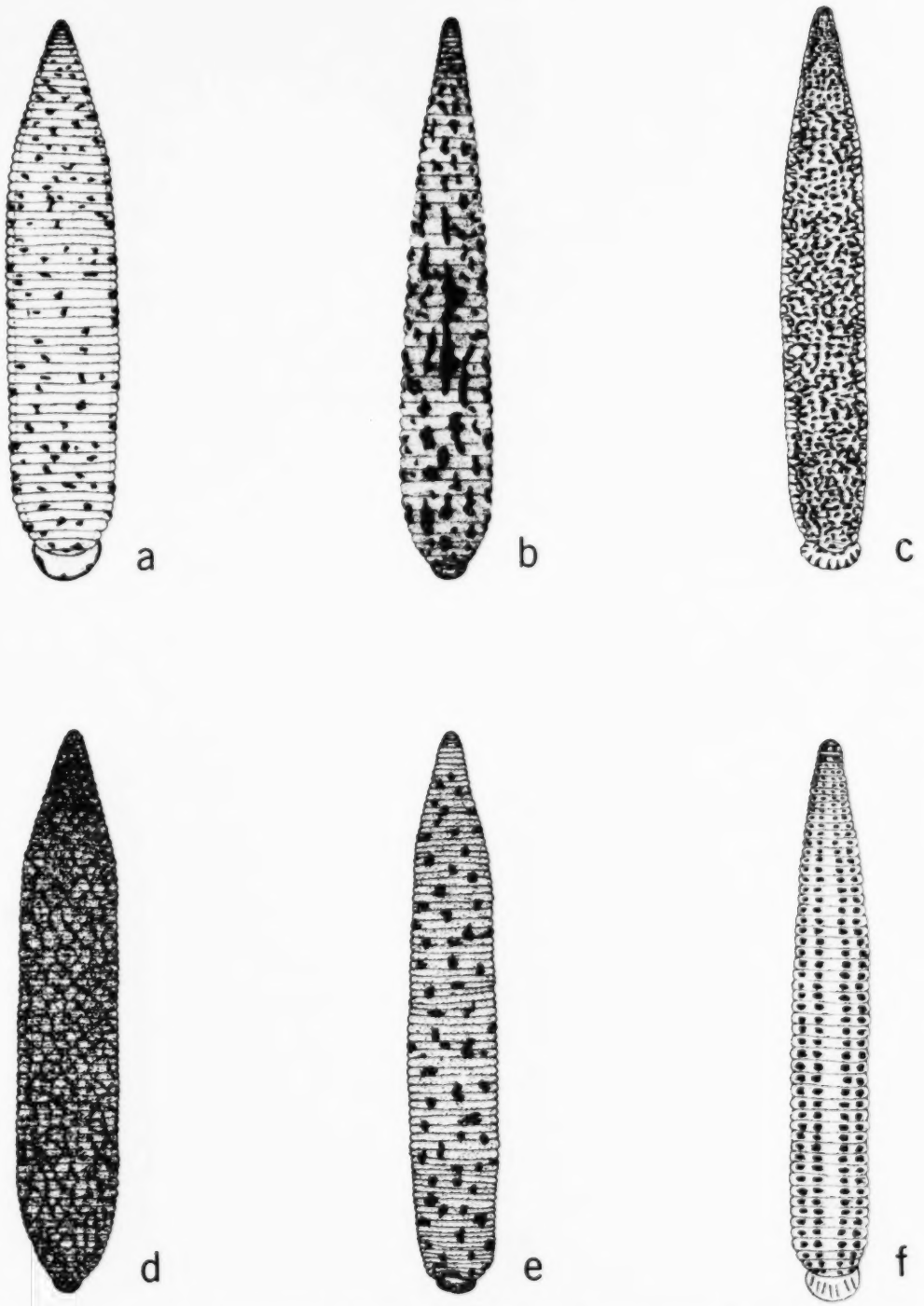


Fig. 26. a- *Bdellarogatis plumbea;* b- *Mollibdella grandis;* c- *Percymoorensis lateromaculata;* d- *P. marmoratis;* e- *Nephelopsis obscura;* f- *Erpobdella punctata.*

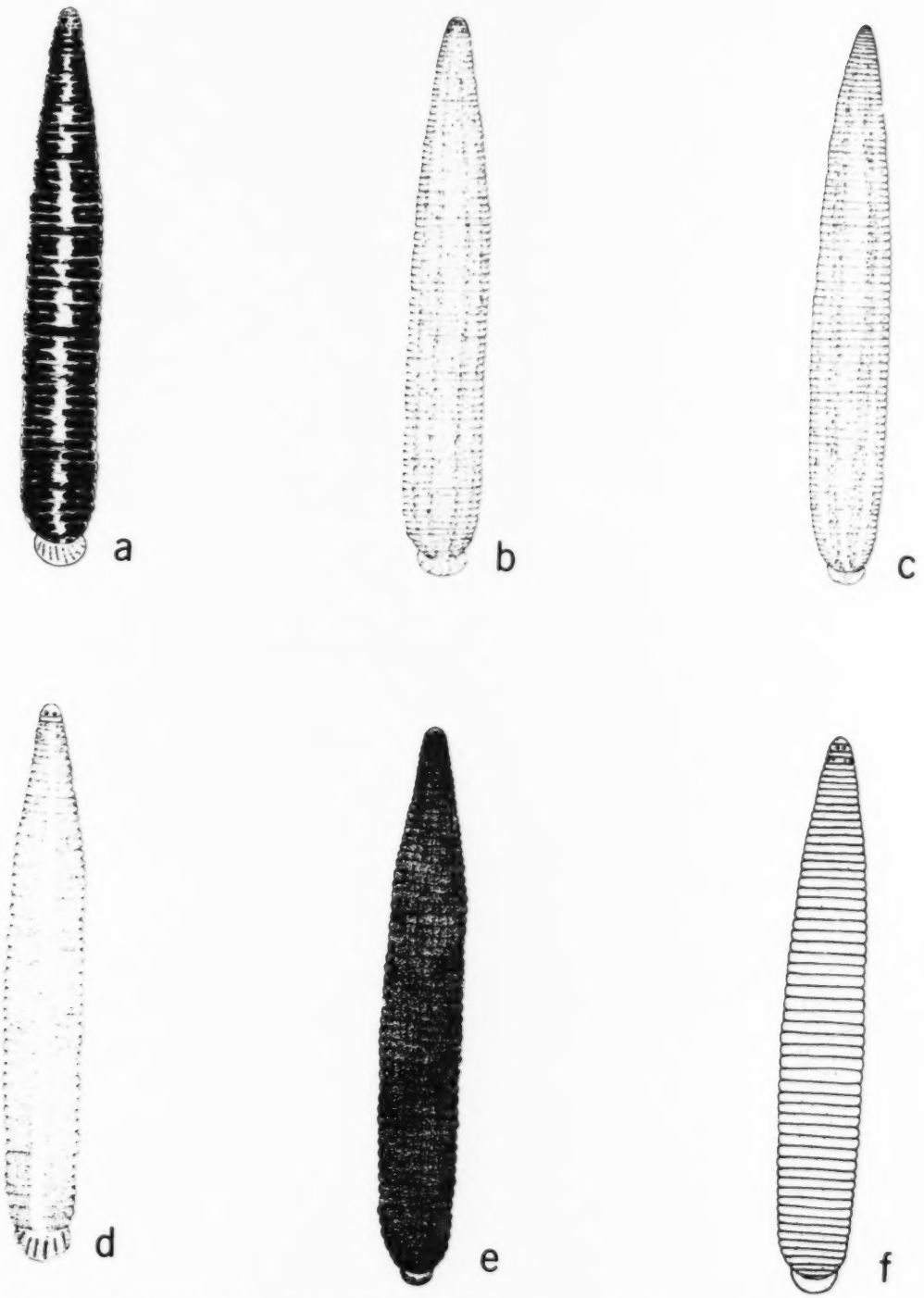


Fig. 27. a- *Erpobdella punctata annulata*; b- *E. triannulata*; c- *Dina anoculata*; d- *D. (Mooreobdella) fervida*; e- *D. (M.) bucera*; f- *D. (M.) microstoma*.

Fig. 28. a- *Dina lateralis;* b- *D. parva;* c- *D. dubia.*

## SECTION IV

## ACKNOWLEDGEMENTS

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## SECTION VI

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